

# The Metabolic Demand of a Vinyasa Yoga Session

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By

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## Abstract

Vinyasa yoga, also known as power flow yoga, is growing in popularity in western cultures. Vinyasa yoga is characterized by moving with the breath and connecting the postures by a series of dynamic movement in between traditional yoga poses. The purpose of this thesis was to determine the intensity and metabolic costs of a typical Vinyasa yoga routine by measuring respiratory gas exchange, heart rate, and perceived rating of exertion. Secondary purposes were to determine whether there were differences between beginner and advanced practitioners and between males and females. Eight beginner (4 males and 4 females) and eight advanced (4 males and 4 females) yoga practitioners were tested while completing a Vinyasa yoga routine. Participants first completed a maximal aerobic test on a treadmill to determine maximal aerobic capacity, and to allow the assessment of relative workload during a subsequent yoga session. After adequate rest, the participant completed a 90-minute familiarization of the Vinyasa yoga session at his or her own skill level. After 4 – 7 days the participants returned, where the beginners completed the beginner routine and the advanced practitioners were randomly assigned to do either the beginner or advanced routine. The advanced practitioners came back on a separate day to complete the routine they had not yet completed. To allow participants to move freely, a portable system (Cosmed K4b2) was used to measure respiratory gas exchange (i.e. oxygen consumption and carbon dioxide output). A heart rate monitor was worn to collect heart rate data. Rating of perceived exertion was measured at set times throughout the session. The mean metabolic equivalents (METs) of Vinyasa yoga (4.7) were significantly higher ( $p < 0.001$ ) than the 3.0 METs needed to achieve a moderate intensity based on the Canadian Physical Activity Guidelines. During the yoga session,  $68 \pm 10$  minutes were spent above 3.0 METs (moderate intensity) and of those minutes,  $16 \pm 16$  were spent above 6.0

METs (vigorous intensity). Based on the Canadian Guidelines for Physical Activity of 150 minutes per week of moderate intensity activity, three 90-minute Vinyasa yoga sessions a week can meet the recommendations for adults.

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# **CHAPTER 1 BACKGROUND AND INTRODUCTION**

## **1.1 Introduction**

Yoga has been practiced for over 4500 years in India as a way to bring union to the mind, body, and spirit (Ramaswami, 2005). Yoga offers a connection between the body and the mind with the ultimate goal being the attainment of enlightenment. There are eight “limbs” in yoga and the asanas (poses or physical practice) are just one of the eight limbs (see Appendix A, Iyengar, B.K.S., 2007). Pranayama (breathing practice) and dhyana (meditation) are another two of the eight limbs that are commonly practiced in yoga classes in Western society (Feuerstein, 2003). The physical portion of yoga involves calisthenic-type movements designed to stretch and strengthen the muscles and to keep the joints of the body flexible. A combination of dynamic and isometric contractions, stretching, relaxation, concentration, and breathing techniques distinguish yoga from other forms of exercise. The asanas are meant to condition the body to prepare it for meditation but there can be many health benefits experienced from it as well.

A review of the literature by Ross and Thomas (2010) has shown that yoga can decrease heart rate and systolic and diastolic blood pressure, have beneficial effects on blood glucose levels in individuals with diabetes, and relieve symptoms associated with multiple sclerosis, menopause, and kidney disease. Furthermore, they note yoga also effectively relieves symptoms of mental illness including depression, anxiety, obsessive-compulsive disorder, and schizophrenia.

Practicing yoga can also increase physical fitness. Tran, Holly, Lashbrook, and Amsterdam (2001) found an increase in muscular strength, muscular endurance, and flexibility in

healthy young adults (mean age;  $22.1 \pm 0.8$ y) after practicing yoga 2 times a week for 8 weeks. These same participants also increased absolute maximal oxygen uptake by 7% and relative maximal oxygen uptake by 6% ( $p < 0.01$ ). A 6-week study also completed in healthy adults ( $n = 26$ , mean age;  $31.8 \pm 10.6$ y) demonstrated a significant improvement in upper body and trunk dynamic muscular strength and endurance, and flexibility (Cowan & Adams, 2005).

With all these potential health benefits, the popularity of yoga, particularly in the Western world, is continuing to grow. In 2001, yoga classes were being offered at 75% of all US health clubs, as well as at yoga studios and in private homes (Corliss & Funderburg, 2001). In 2008, 6.9% of adults or 15.8 million people in the United States practiced yoga. Of the people not currently doing yoga, nearly 8% or 18.3 million Americans said they were extremely interested in yoga and 4.1% or 9.4 million Americans said they would definitely try yoga within the next year (Macy, 2008). Although no similar statistics or values are available for Canada, the U.S. numbers show the already large and growing interest of yoga in Western culture. In the same study 6.1% or nearly 14 million Americans said a doctor or therapist had recommended yoga to them. With more and more people doing yoga, clearer information and guidelines regarding the physiological and metabolic benefits should be available for all types of yoga. The intent of this study is to determine the metabolic demands and energy expenditure of Vinyasa yoga.

## **1.2 Literature Review**

### **1.2.1 Different Forms of Yoga**

There are many different types of yoga. If health practitioners are recommending yoga for health benefits, the basic physical and physiological demands of each type of yoga should be understood to ensure it is appropriate for the patient. Hatha yoga is a general term for the

physical practice of yoga; however, in North America if a studio lists Hatha yoga as an option it will most likely be a more gentle class than other types.

Iyengar yoga focuses on proper alignment and the poses are generally held for a longer period of time. Iyengar yoga encourages the use of props and aids (e.g. blocks and belts) while executing the pose. In contrast, Vinyasa yoga tends to flow from one pose to the next in a quicker manner. Vinyasa in Sanskrit means to place in a special way with the synchronization of breath: it is characterized by moving with the breath and connecting the postures by a series of dynamic movements in between longer held yoga poses (Ramaswami, 2005). An image of these transition movements can be seen in Appendix B. Vinyasa yoga, also known as power yoga or flow yoga, also incorporates *Ujjayi* breath. It is created by constricting the glottis in the throat, which creates a turbulence and resistance to the air as it enters and exits the lungs. The emphasis of this breath is to take in even, deep inspirations and expirations as opposed to shallow, sporadic ones. Vinyasa yoga also stresses the use of *Bandhas* (translates to English as locks) such as activating the deep abdominal muscles and pelvic floor muscles to assist with spinal stability. This continuous flow between poses helps to generate internal heat (Baptiste, 2002). A typical Vinyasa yoga class usually lasts in between 60 to 90 minutes.

### **1.2.2 Energy Expenditure of Yoga**

Several studies on the energy demands of traditional Hatha yoga have been carried out (Clay, Lloyd, Walker, Sharp, & Pankey, 2005; DiCarlo, Sparling, Hinson, Snow, & Roskopf, 1995; Ray, Pathak, & Tomer, 2010) although they do not have the dynamic movement in between postures, but rather more stationary poses. Few studies have focused on Vinyasa yoga, which does incorporate the dynamic movement in between poses. Research carried out on Hatha yoga has demonstrated that the energy demands are relatively low and that a single yoga session

would not be sufficient to acquire any cardiorespiratory improvements (Clay et al., 2005; Hagins, Moore, & Rundle, 2007). This was based on the American College of Sports Medicine (ACSM) Position Stand (Garber et al., 2011) which recommends that adults engage in moderate-intensity cardiorespiratory exercise training for  $\geq 30$  minutes per day on  $\geq 5$  days of the week for a total of  $\geq 150$  minutes per week, vigorous-intensity cardiorespiratory exercise training for  $\geq 20$  minutes on  $\geq 3$  days per week ( $\geq 75$  minutes per week), or a total combination of moderate and vigorous intensity exercise to achieve a total energy expenditure of  $\geq 1000$  kcal/week. A moderate intensity activity would be equal to working in a range of 3 to 5.9 metabolic equivalents (METs) (Pollock et al., 1998).

The recent (2011) Canadian Physical Activity Guidelines (Canadian Society for Exercise Physiology, 2012) are similar and suggest accumulating at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more. Following this guideline can aid in the prevention of cardiovascular disease, stroke, breast cancer, hypertension, colon cancer, type 2 diabetes, and osteoporosis (Warburton et al., 2010). Moderate intensity aerobic physical activity would be equal to 40% - 69% of heart rate reserve or 3 – 6 METs and vigorous intensity would be 60% - 84% of heart rate reserve or 6 – 8 METs (Warburton, Nicol, & Bredin, 2006). Heart rate reserve can be calculated using the formula:  $(\text{working heart rate} - \text{resting heart rate}) / \text{predicted maximal heart rate}$  (Warburton et al., 2006).

METs are a measure to express energy cost. Jette, Sidney & Blumchen (1990) define one MET “as the resting metabolic rate, that is, the amount of oxygen consumed at rest, sitting quietly in a chair, approximately 3.5 ml O<sub>2</sub>/kg/min”. This would be equal to an oxygen consumption of about 250 mL/min for the average 70 kg individual. Assuming 5 kcal per L of oxygen consumed, this equals an energy expenditure of 1.25 kcal/min. Three METs would be

three times the metabolic rate of sitting quietly or about 3.75 kcal/min. Metabolic equivalents can be calculated by dividing the relative oxygen cost by 3.5 ( $\text{O}_2/\text{kg}/\text{min} \div 3.5$ ). The benefits of using METs are that they are relative to body size (kg). One MET is the unit of energy at rest for everyone even if one is large or small. METs are also simple, easily understood and easy to calculate. Some of the limitations of METs are that they do not take into account the amount of lean body mass. Two individuals with the same mass but differences in percent body fat and lean body mass will have different resting metabolic rates. The resting value of 3.5 ml of  $\text{O}_2/\text{kg}/\text{min}$  is an approximate value. The metabolic cost of an activity may also vary depending on environmental factors including temperature, humidity, altitude, terrain, and clothing (Jette et al., 1990).

In an hour-long Ashtanga yoga session (a type of Vinyasa yoga with a set series of poses), the mean energy expenditure was 3.2 kcal/min and the mean METs was 2.5 (Hagins et al., 2007). This intensity was not enough to meet the minimum recommendation of 3.0 METs based on the Canadian Guideline for Physical Activity or ACSM's positional stand on physical activity; however, in this particular study the participants were intermediate to advanced yoga practitioners and completed a beginner level yoga practice. Had participants completed an advanced yoga routine more appropriate to the participants' skill level, higher MET values may have been reached, surpassing the threshold for moderate-intensity physical activity.

Another study investigating the metabolic cost of a 30-minute Hatha yoga routine found a mean METs of 2.17, which was significantly less than walking on a treadmill at 3.5mph (4.62 METs)(Clay et al., 2005). This routine, however, included only 5 minutes of sun salutations, a series of 12 standing poses that elicited a higher heart rate (67% maximum heart rate; MHR) and MET value (3.74), whereas the rest of the routine was significantly lower (56% MHR and 2.07

METs). The authors suggested a yoga routine with more “sun salutations and series of asanas similar to the sun salutations will greatly increase energy expenditure”.

Ray et al. (2010) found during an hour-long Hatha yoga session the majority of the poses elicited 1 – 2 METs with only three poses going above 2 METs. During this routine there were no standing poses, which demonstrate a significantly higher physiological response than seated poses (Blank, 2006). In the study by Ray et al. (2010), throughout the yoga routine in between poses, the participants were instructed to go into savasana (a supine relaxation position), which is typical of a traditional Hatha yoga program. This would not allow for any cumulative effect from previous poses. Without a supine rest in between poses this would allow heart rate and the energy expenditure to increase due to the efforts of the prior pose. Completing savasana in between poses is not usual during a Vinyasa yoga routine. More commonly, in replacement of savasana, participants complete a vinyasa (a series of moving poses linked with ujjayi breath and with held bandhas, see Appendix B) to transition to the next pose, which would likely increase energy expenditure.

Cowan and Adams (2005) investigated the physical outcomes of Ashtanga yoga and Hatha yoga over a 6-week period. The Ashtanga yoga group decreased diastolic blood pressure and perceived stress, and increased upper body and trunk dynamic muscular strength and endurance, flexibility and health perception. The Hatha yoga group only improved trunk dynamic muscular strength and endurance, and flexibility. Cowan and Adams (2007) subsequently compared the heart rate of participants practicing different styles of yoga; Ashtanga yoga, Hatha yoga, and gentle yoga. While completing Ashtanga yoga, the participants had significantly higher heart rates compared to Hatha yoga and gentle yoga. There was no



significant difference in heart rate between Hatha yoga and gentle yoga. The results from these two studies suggest that different styles of yoga may elicit different physiological responses.

Heart rate response during a Hatha yoga routine was disproportionately high relative to the oxygen consumption (Clay et al., 2005; DiCarlo et al., 1995). Clay et al. (2005) speculated that this disproportionately high heart rate could be due to an increase in venous pooling occurring during static poses. This would reduce venous return and stroke volume, necessitating an increase in heart rate to maintain cardiac output. Measures of heart rate alone may therefore not be sufficient to determine the intensity level. It is important to measure the gas exchange of the participants completing the yoga routine to get an accurate measure of intensity and to be able to determine the metabolic cost involved.

Despite the popularity of Vinyasa yoga, little research has been performed to determine the metabolic cost involved in a typical yoga practice. Some have measured portions of a yoga session and specific poses (Mody, 2011; Carroll, Blansit, Otto, & Wygand, 2003) but very few have measured a complete yoga practice. When participants were tested completing sun salutations (a series of dynamic movements usually used near the beginning of a session to warm up) during a Vinyasa routine, they were shown to be working at 50% of their maximal oxygen consumption ( $\text{VO}_2 \text{ max}$ ), 77% of their maximal heart rate and have a caloric expenditure of 7.15 kcal/min. Vinyasa yoga had a calculated energy cost of 6.7 METs (Carroll et al., 2003). This study only measured 15 minutes of sun salutation, which is argued to be the most energy intensive portion of a yoga session. Another study that looked at 4 rounds of sun salutations found the participants were exercising at an average intensity of 80% of their maximum heart rate (Mody, 2011).

### **1.2.3 Challenges of Measuring Energy Expenditure**

Energy expenditure can be measured in different ways. Direct calorimetry using a room or chamber calorimeter measures the amount of heat produced by the subject and can give accurate measures of energy expenditure (i.e. 1 - 2% error) for long periods of time. These chamber calorimeters however are expensive and “require at least one full-time, highly skilled technician to maintain, validate, calibrate and use the instrument” (Levine, 2005). Indirect open-circuit calorimeters can be just as accurate as direct calorimetry over the short-term and are less expensive to purchase and maintain. These systems are simple and do not require such high skill to calibrate and use. In the last couple of decades advances in these systems has allowed them to become more portable. The Cosmed K4B<sup>2</sup> unit is an expiratory collection open-circuit system. The mask is connected to a one-way valve where the flow rate of the expired air is measured and concentrations of its gases are analyzed (Levine, 2005). The subject breathes room air and does not need large tubes or long cords. This is important because it allows the subject to move freely and unencumbered while performing physical activity. The majority of past studies which have measured the metabolic cost of yoga have used some form of portable open-circuit calorimeter system such as the Oxycon Mobile Metabolic System, Erich Jaeger, Germany (Blank, 2006; Mody, 2011; Sinha, Ray, Pathak, & Selvamurthy, 2004). One study used a respiratory chamber (Hagins et al., 2007).

Other modalities of exercise such as Tai Chi have also used similar portable metabolic systems. Tai Chi is somewhat similar to yoga in that it is a series of bodyweight movements that require physical and mental focus to link the postures with the breath. A study evaluated the cardiorespiratory response and energy expenditure of Tai Chi Qui Gong using a Cosmed K4 telemetry system (Choa, Chen, Lan, & Lai, 2002). This system worked well for this type of

activity since it allowed the subjects to move freely while collecting accurate measurements. The results of this study demonstrated that the intensity of Tai Chi is about 3 METs and that it was an appropriate alternative exercise for cardiopulmonary rehabilitation.

Another similar type of exercise to yoga would be basic calisthenics. Basic calisthenics movements (i.e. standing hip flexion and extension, trunk rotations, lateral side bends, arm circles and standing knee raises) ranged in MET values from 2.0 to 4.5. (Greer, Weber, Dimich, & Ratliff, 1980). One study specifically looked at lower body and upper body calisthenics and found that they range from 4 to 6.5 METs and 2 to 3.5 METs, respectively (Cassidy & Nielsen, 1992). Yoga uses a combination of both upper body and lower body movements simultaneously but the practitioners would most likely move at a slower cadence and hold poses for longer than a repetitive calisthenics sequence. Knowing the energy expenditure of these similar exercise modalities evokes the urge to explore what it might be for Vinyasa yoga.

#### **1.2.4 Beginner versus Advanced**

At this point, it remains unclear if beginner and advanced yoga practitioners respond similarly to a Vinyasa yoga program in terms of energy expenditure or breathing efficiencies. Skill level may affect the physiological response since with time one would expect to better execute a pose, therefore subtly changing it.

A recent study determined the arterial blood pressure and cardiovascular response between beginner and advanced practitioners while doing Hatha yoga. Although mean arterial blood pressure, heart rate and cardiac output all significantly increased from baseline, no difference between beginner and advanced practitioners was shown (Miles et al., 2013). This was the first study to compare novice and intermediate/advanced yoga practitioners. Many have

measured beginner yoga practitioners only (Clay et al., 2005; Tran et al., 2001, Ray et al., 2001) or intermediate to advanced yoga practitioners only (Hagins et al. 2007; Ray et al., 2010). None have compared the two groups to each other in terms of metabolic cost. Since a beginner may be less efficient with the poses while completing Vinyasa yoga, it is expected that a beginner may have a higher relative work rate than an advanced practitioner. That is, beginners should have a higher work rate when doing a beginner routine compared to the advanced group doing the same beginner routine. On the other hand, more advanced Vinyasa yoga practitioners would be expected to attempt more difficult poses during an advanced routine, which could possibly increase absolute work rate. The advanced practitioners should therefore be working at a higher work rate when doing an advanced routine compared to the beginners when doing a beginner routine.

Any differences between the physiological responses to Vinyasa yoga among beginner and advanced yoga practitioners is important to study as it may help an individual determine if this type of yoga is appropriate for them. For example, knowing the energy expenditure of Vinyasa yoga can possibly encourage an athletic individual who otherwise might have dismissed yoga as “too slow” or “too boring” to participate. Conversely, the results may show Vinyasa yoga may be “too intense” for less fit populations or for people with health conditions in which more physically demanding activities may be contraindicated.

## **1.3 Statement of the Purpose and Hypothesis**

### **1.3.1 Purpose**

The energy expenditure and intensity of a typical Vinyasa yoga session is currently unknown or has not been reported in the scientific literature. Therefore, the primary purpose of

this thesis was to determine the intensity and metabolic costs of a typical 90-minute Vinyasa yoga routine by measuring gas exchange and heart rate in adult (ages 18 – 45y) men and women. The secondary purpose of the study was to compare the differences in the metabolic demand and rating of perceived exertion between beginner and advanced yoga practitioners while completing the same beginner Vinyasa yoga routine and while completing a skill-appropriate Vinyasa yoga routine.

### **1.3.2 Hypotheses**

The following hypotheses were tested.

1. That completing a 90-minute Vinyasa yoga session would be sufficient to meet the energy demands of at least 3 METs to improve cardiovascular fitness based on the Canadian Guidelines for Physical Activity.
2. That a beginner yoga practitioner would be working at a higher relative work rate than an advanced yoga practitioner when both groups complete the same yoga routine but that an advanced practitioner would be working at a higher absolute work rate than a beginner while completing a skill-level appropriate Vinyasa yoga routine (i.e. advanced practitioners completing an advanced routine and beginners completing a beginner routine).

## **CHAPTER 2 METHODS**

### **2.1 Participants**

Males and females between the ages of 18 and 45y were recruited for the study. The recruitment goal was 26 participants; 13 per skill group. Both beginner and advanced participants were recruited by posters in various local yoga studios. A beginner included anyone who had been doing yoga for one to six months. All beginner participants were required to have completed at least one month of formal yoga classes to ensure competency to complete the protocol and reduce the risk of injury. The inclusion criterion to qualify as an advanced participant were yoga practitioners who have been practicing for more than three years of formal yoga practice and a) performs Ujjayi breathing (a breathing method meant to be executed throughout the yoga practice), b) are comfortable carrying out inversions (headstand, shoulder stand), and c) are competent in completing sun salutations. All participants were free of any injuries or limitations that would prevent them from completing the testing protocol. Based on spirometry results none of the participants had any breathing abnormalities. All participants were able to complete all the poses of the yoga sessions. Participant characteristics are shown in Table 3.1 of the results.

### **2.2 Measurements**

Height, weight, resting blood pressure and resting heart rate were measured prior to commencing any testing and the Canadian Society for Exercise Physiology – Physical Activity Training for Health (CSEP-PATH, 2013) protocol was used. Briefly, the protocol for height and weight were as follows. Height was measured using a meter stick against the wall. Without wearing shoes, the participant stood with feet together and heels and back against the wall. While

looking straight ahead a flat edge was placed on the participant's head to depress the hair. The measurement was taken on an inhale and was recorded to the nearest 0.1 cm. Weight was measured on a digital scale (Toledo<sup>®</sup>, Australia) by asking the participant to stand on the scale with no shoes and minimal clothing. Weight was recorded to the nearest 0.1 kg. Blood pressure was taken after sitting for at least 5 minutes with feet flat on the floor and arms on the arm rests. A blood pressure cuff (ALMEDIC, Montreal) of appropriate size was placed on the upper arm above the bend of the elbow and inflated to 30-40 mmHg above the point where the radial pulse is no longer palpable. With a stethoscope over the brachial artery, the systolic blood pressure was determined by the first perception of sound and the diastolic was determined by the disappearance of sound. Blood pressure was recorded on a wall model mercurial sphygmomanometer (Fitsystems, Cochrane, Canada) to the nearest 2 mmHg. Resting heart rate was measured after resting blood pressure while the participant remained in the same seated position. The radial pulse was palpated for a 15-second count and then multiplied by 4 to determine that participant's beat per minute reading. Whole numbers were used.

Spirometry was performed using the VMAX<sup>™</sup> Encore Metabolic Cart (Viasys Healthcare Respiratory Technologies) to measure pulmonary function. A physical therapy professor specializing in pulmonary exercise physiology independently reviewed the results and ruled out any preexisting disorders. Direct calorimetry using a chamber calorimeter was not available for the current study therefore indirect open-circuit calorimetry was used. The K4 b<sup>2</sup><sup>®</sup> (Cosmed USA, Chicago, IL) is a portable wireless oxygen exchange system that measures respiratory exchange ratio (RER), oxygen uptake ( $\text{VO}_2$ ), carbon dioxide elimination ( $\text{VCO}_2$ ), relative  $\text{VO}_2$  (oxygen uptake expressed per unit of body weight), percent  $\text{VO}_2$  reserve ( $\%\text{VO}_{2\text{R}}$ ), breathing frequency (Rf), minute ventilation (VE) and tidal volume (Vt). The whole apparatus

weighs approximately 800 grams and straps on to the participant's chest with a harness. This allows them to move freely through the yoga poses. The mask was fitted to each participant to reduce air leaks and covered the mouth as well as the nose, as shown in Figure 2.2 and 2.3. This is important during yoga because it is encouraged to breath in and out through the nose. The portable system allowed the participant to move through the yoga poses with very minimal restriction. Prior to each testing session, the K4b<sup>2</sup> unit was calibrated against ambient air (20.93% for O<sub>2</sub> and 0.03% for CO<sub>2</sub>) and reference air (16.00 % for O<sub>2</sub> and 5.00% for CO<sub>2</sub>). The turbine calibration consisted of measuring the volume of a 3-liter calibration syringe at low, medium, and high flow velocities. The Cosmed K4b<sup>2</sup> system was tested for accuracy against the Douglas bag method and it was found to be acceptable over a wide range of exercise intensities (McLaughlin, King, Howley, Bassett, & Ainsworth, 2000). Test-retest trials were performed using the K4b<sup>2</sup> system by Duffield, Dawson, Pinnington and Wong (2004) to determine the reliability of the portable system. The test-retest trials had a strong intraclass correlation coefficient (0.7 – 0.9,  $p < 0.05$ ) between an easy 10-minute run as well as a hard 3-minute run. This showed that on different days the Cosmed K4b<sup>2</sup> system had low levels of systematic error or error variance.

Energy expenditure in METs was calculated with the following formula: Relative VO<sub>2</sub> (mL/kg/min) / 3.5 (Warburton et al., 2006). METs were chosen in this study because this unit can be easily compared to other activities as well as the Canadian Physical Activity Guidelines. Energy expenditure in kcal/min was determined using the calculation derived by Weir (1949). It was as follows: kcal/min =  $([1.1 \times \text{RER}] + 3.9) \times \text{VO}_2$ . Percent VO<sub>2</sub> reserve was determined by the formula: % VO<sub>2</sub>R =  $(\text{working VO}_2 - 3.5) / (\text{VO}_2 \text{ max} - 3.5)$ , in which the value 3.5mL/kg/min was assumed to be the average resting VO<sub>2</sub> of the subject (Swain & Franklin, 2002).



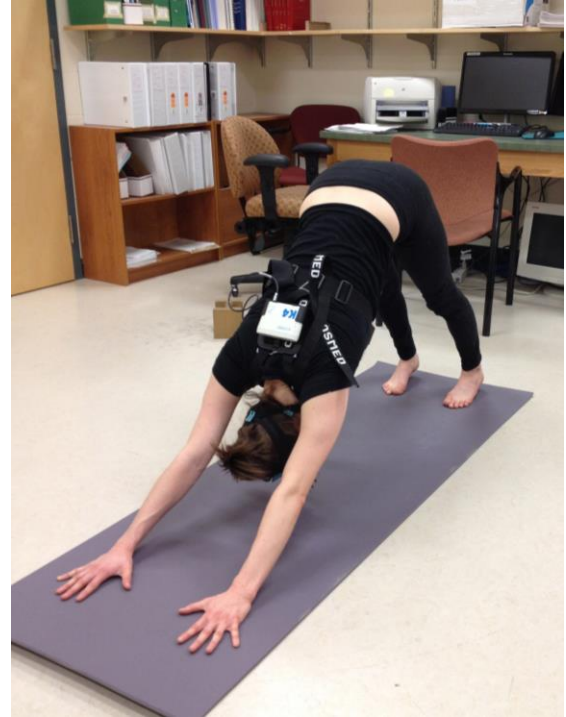
Heart rate was continuously collected using the POLAR® heart rate monitor belt around the participant's chest and percentage of heart rate reserve was calculated. Rating of perceived exertion was recorded using the 10-point Borg Scale of Perceived Exertion (Borg, 1982) to determine how hard the participant felt they were working. (Please see Figure 2.1 for Borg Scale of Perceived Exertion). The participant was shown the Borg Scale of Perceived Exertion before starting exercise to familiarize them with it. At set time periods throughout the yoga session the participant was shown the scale again and asked to honestly assess their level of exertion (please see Table 2.1 for Beginner Yoga Sequence and Table 2.2 for Advanced Yoga Sequence and respective measurement time periods).

0	Nothing at all	
0.5	Very, very weak	(just noticeable)
1	Very weak	
2	Weak	(light)
3	Moderate	
4	Somewhat Strong	
5	Strong	(heavy)
6		
7	Very Strong	
8		
9		
10	Very, very strong	(almost max)
	Maximal	

**Figure 2.1 Rating of Perceived Exertion**  
(Borg, 1982)



**Figure 2.2 Front View of Cosmed K4b<sup>2</sup>**  
Participants were fitted with a size appropriate mask (small, medium or large) and the Cosmed K4b<sup>2</sup> system was worn using a harness.



**Figure 2.3 Back view of Cosmed K4b<sup>2</sup>**  
A small battery pack was worn on the back also using the harness.

## 2.3 Procedures

After informed consent (see Appendix C) was obtained, all participants completed a Physical Activity Readiness Questionnaire (see Appendix D) (Thomas, Reading, & Shephard, 1992) to ensure they could safely participate in activity. If the participant answered yes to certain questions (i.e. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?) then that participant would be referred to their medical doctor before proceeding with physical activity. No participants required further clearance from a medical doctor. Participants were instructed not to have caffeine or food within the 4 hours prior to testing and did not do any heavy exercise the day of testing. All measurements were taken in an exercise physiology lab and not in a yoga studio. The temperature in the laboratory ranged from 21°C to 25°C. A full volume loop was measured through spirometry using the VMAX™ Encore Metabolic Cart (Viasys Healthcare Respiratory Technologies) to rule out any breathing abnormalities. The participants then completed a VO<sub>2</sub> max test to determine maximal aerobic capacity (Canadian Society for Exercise Physiology, 1996). The VO<sub>2</sub> max score was used to determine the percentage of maximal workload that the participants were working at while completing the yoga session. The VO<sub>2</sub> max test was an incremental test on a treadmill until volitional failure, and was completed using the K4 b<sup>2</sup>® unit for consistency. The speed that the participant was running at during the test was determined during a 5-minute warm-up. The speed remained constant throughout the test and the incline was increased by 2% every 2 minutes until volitional fatigue by the participant. The test was deemed a true VO<sub>2</sub> max if the participant met four criteria; 1) volitional fatigue, 2) attained predicted maximum heart rate (220-age), 3) achieved an RER value greater than 1.1, and 4) a plateau in VO<sub>2</sub>. After adequate rest participants performed the 90-minute Vinyasa yoga program as a

familiarization to the protocol. This ensured they could complete the yoga routine as well as become accustomed to it. Participants wore the portable oxygen exchange device but no measurements were taken during the familiarization test. Beginner practitioners completed a familiarization of a beginner routine and the advanced practitioners completed a familiarization of an advanced routine. The second visit occurred no fewer than 3 days after the initial visit to allow adequate recovery. Participants were asked to avoid any vigorous exercise the day before this visit. The beginner practitioners completed the 90-minute beginner yoga routine. The advanced practitioners completed either the 90-minute beginner yoga routine or the 90-minute advanced yoga routine. The order of which routine was completed first was alternated for each advanced practitioner so that an equal number of practitioners were completing the beginner routine first. Only advanced yoga practitioners were required to come back for a third session. This session was completed 3 – 10 days after the last visit and the participant was asked to not do any vigorous exercise the day before this session. On this visit the advanced participant completed either the beginner or advanced routine, whichever routine had not yet been completed.

Heart rate,  $\text{VO}_2$ ,  $\text{VCO}_2$ , RER, relative  $\text{VO}_2$ , VE, Rf, and VT were measured continuously. Ratings of perceived exertion were also tested throughout the program at set intervals (please see Table 2.1 and 2.2 for measurement time points).

## **2.4 The Yoga Program**

The Baptiste Journey Into Power flow was used as the Vinyasa yoga routine (Baptiste, B., 2002). Vinyasa classes are known for their variety with no set sequence but do follow a rough guideline which includes starting the class with centering the mind followed by a warm up, typically involving sun salutation, and then on to the more challenging standing and balance

poses. Backbends and abdominals generally come after the standing poses and the class usually winds down with passive stretches on the floor. The class concludes with savasana which is a relaxation pose performed while lying on your back. The Baptiste Journey Into Power routine was chosen because it is a good example of what a typical Vinyasa class would be like. It is also well known and widely available (Baptiste, 2002). Due to the portable K4b<sup>2</sup> unit being on the chest and the battery being on the back, three yoga poses needed to be eliminated from the routine. These poses were locust pose, bow pose and shoulder stand (advanced practitioners only). This routine was a 90-minute video recording of an “all-levels” class. The Vinyasa class was led by a local Vinyasa yoga instructor who was Baron Baptiste Power Institute Trained. Although the yoga program flowed continuously, it was broken down into 3 sections for comparison purposes. The sections included 1) sun salutations, 2) standing poses, balance poses, and backbends, 3) abdominal poses, seated poses, and final relaxation. See Table 2.1 and 2.2 for a more in depth list of all the poses. All the participants followed the same base practice with variations depending on personal skill level. The beginner routine had more advanced poses taken out and was 10 minutes shorter (80 minutes total). The investigator recorded the different variations a participant chose to execute. It was up to the participant to choose the variation that was best suited to their ability. Options of variations were given and the participants were instructed to challenge themselves but to maintain an even breathing pattern as one would expect of an all levels Vinyasa class.

**Table 2.1 Beginner Yoga Sequence**

Poses	Sections		
Child's pose	First 5 minutes not included in part 1	Triangle	Part 2 continued Standing poses
Downward facing dog		Side Facing Wide Leg Forward Bend	
Ragdoll		Namaste Front Facing Forward Fold	
Mountain pose	Part 1 Sun salutations	Twisting Triangle	
Sun Salutation A x5		RPE	
Sun Salutation B x5		Upward Facing Dog/Cobra	
RPE	Part 2 Standing poses	Single Camel	
Sun Salutation B Variation		Bridge x3	
Crescent Lunge into twist		Bridge	
Extended Side Angle		RPE	
Vinyasa into other side		Scissor Legs and 60/30 Lift	Part 3 Floor
Thunderbolt prayer twist		Abdominal Twists	
Fingers to toes Forward fold		Boat Pose x3	
Palms to toes Forward fold		RPE	
Crow Pose		Half Pigeon	
RPE		Double Pigeon	
Eagle Pose			
Dancer's Pose		Seated Single Leg Extension	
Standing Leg Raise		Seated Forward Bend	
Airplane		Table Top (bent legs)	
Tree		RPE	
RPE		Supine Twist	
Sun Salutation B Variation		Happy baby	
		Corpse Pose	

**Table 2.2 Advanced Yoga Sequence**

Poses	Sections	Sun Salutation B Variation	Part 2 continued Standing poses
Child's pose	First 5 minutes not included in part 1	Triangle	
Downward facing dog		Side Facing Wide Leg Forward Bend (option for tripod headstand)	
Ragdoll		Namaste Front Facing Forward Fold	
Mountain pose		Twisting Triangle	
Sun Salutation A	Part 1 Sun salutations	RPE	
Sun Salutation B		Upward Facing Dog	
RPE	Part 2 Standing poses	Single Camel	
Sun Salutation B Variation		Wheel x3	
Flip dog/side plank		Bridge	
Sun Salutation B Variation		RPE	
Crescent Lunge into twist		Scissor Legs and 60/30 Lift	Part 3 Floor poses
Extended Side Angle (option for Bird of paradise)		Abdominal Twists	
Vinyasa into other side		Boat Pose x3	
Thunderbolt prayer twist (option for side crow)		RPE	
Fingers to toes Forward fold		Half Pigeon (option for backbend)	
Palms to toes Forward fold		Double Pigeon	
Crow Pose (option for headstand/handstand)			
RPE		Seated Single Leg Extension	
Eagle Pose		Seated Forward Bend	
Dancer's Pose		Table Top	
Standing Leg Raise		RPE	
Airplane		Headstand	
Half Moon		Child's pose	
Tree			
RPE		Supine Twist	
		Happy baby	
		Corpse pose	
		RPE	



## 2.5 Sample Size and Analysis

The sample size calculation was based on kcal/min measurements from Hagins et al. (2007) and Clay et al. (2005). The mean value for beginners was 2.23 (SD 0.57) kcal/min (Clay et al, 2005) and the mean value for intermediate to advanced was 3.2 (SD 1.1) kcal/min (Hagins et al, 2007.) With the alpha level set at 0.05 and a power of 80%, the required n for each group was 13 participants.

Independent t-tests were used to distinguish if the beginner and advanced groups differed with respect to mean age, weight, height, BMI and VO<sub>2</sub> max.

For hypothesis one, to determine the energy expenditure and intensity of a typical Vinyasa yoga session, the mean METs of all the participants working at all intensity levels were calculated. Beginner practitioners were measured while completing a beginner routine and the advanced practitioners were measured while completing an advanced and beginner routine. The reason for this was to account for all effort levels. An advanced practitioner, for example, may go to a class on a particular day and not feel like putting forth their best effort or attempting more difficult poses when given the option. By pooling all the means as opposed to only using the skill appropriate data (beginner completing beginner routine and advanced completing an advanced routine) it makes for more conservative results but also a more applicable outcome that may mimic “real-world” scenarios. A one-sample t-test was run against the known mean of 3.0 METs to determine if the energy expenditure in a Vinyasa yoga session was greater than the minimum needed to meet the Canadian Physical Activity Guidelines (Warburton et al. 2006; Garber et al, 2011).

For hypothesis two, a three-way (2 x 2 x 3) Analysis of Variance with repeated measures was used to determine if there were differences in METs, kcal/min, % VO<sub>2max</sub>, % VO<sub>2R</sub>, %

MHR, % HRR, RPE and respiratory measures between beginner and advanced yoga groups during set time points of the routine. Sex was included as a factor in the analysis as an equal number of male and female were participants. If sphericity was not met (i.e. the variances of the difference between all the possible pairs of the groups are not equal) while running the interactions then a Greenhouse-Geisser adjustment was used to correct the degrees of freedom. This protects against a Type 1 error which may be more likely if the assumption of sphericity is not met. The first factor in this ANOVA was therefore a between-groups factor (i.e. beginner vs. advanced), the second was a between-groups factor (i.e. male vs. female) and the third was a within (repeated measures) factor (i.e. time). The yoga routine was grouped into 3 sections (time points) for the repeated measures: time point 1) sun salutations; time point 2) standing poses; and time point 3) floor poses (see Table 2.1 and Table 2.2). The measures were averaged across each of the 3 sections. The first 5 minutes of the routine was not used due to variability in the measures. When significant differences were found, a Bonferroni multiple comparisons test was run to compare across time points and independent t-tests were run between groups.

To determine if the beginner group differed significantly than the advanced group in relative work rate (i.e. METs, kcal/min, % VO<sub>2</sub> max, % VO<sub>2</sub>R, % MHR, % HRR, RPE and respiratory measures), the two groups were compared at set time points throughout the same beginner yoga routine. To determine if advanced yoga practitioners are working at a higher absolute work rate than the beginner practitioners (i.e. METs, kcal/min, % VO<sub>2</sub> max, % VO<sub>2</sub>R, % MHR, % HRR, RPE and respiratory measures), both groups were compared at the appropriate skill level: advanced practitioners completing an advanced routine and beginner practitioners completing a beginner routine. Males and females were compared as well in both relative work rate and absolute work rate to see if there was a sex difference since the equal number in each

sex group worked in favour for this comparison. Significance was set at  $p < 0.05$  unless a Bonferroni adjustment was used in which case significance was set at  $p < 0.017$  (i.e.  $0.05/\text{number of comparisons}$ ). The results were presented as means and standard deviations.

## CHAPTER 3 RESULTS

### 3.1 Characteristics of Participants

Eight beginner participants and 8 advanced participants were recruited. The beginner and advanced group had an equal number of males and females (4 males and 4 females per group). . All the advanced participants were Vinyasa yoga instructors, although this was not an inclusion criterion, and had a mean of 8.4 years practicing (range 3 – 18 years). The beginner group had a mean experience of 2.75 months (range 1 – 6 months). The goal of 13 participants per skill group was not reached in the time allotted for the project. No significant differences were evident between skill groups in any of the baseline characteristics except age ( $p = 0.02$ ). The groups were fairly well matched (Table 3.1).

		Age (years)	Weight (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )	VO <sub>2</sub> max (mL/min/kg)
Beginner (n=8)	Male (n=4)	27 ± 7	80.9 ± 11.5	179.8 ± 9.8	24.9 ± 1.2	45.5 ± 6.5
	Female (n=4)	25 ± 3	56.7 ± 6.9	165.1 ± 4.7	20.8 ± 2.8	38.2 ± 6.6
		<b>26 ± 5</b>	<b>68.8 ± 25.6</b>	<b>172.4 ± 10.6</b>	<b>22.9 ± 2.9</b>	<b>41.9 ± 7.2</b>
Advanced (n=8)	Male (n=4)	37 ± 8	74.3 ± 10.0	175.6 ± 6.5	24.0 ± 2.1	43.7 ± 6.6
	Female (n=4)	31 ± 9	59.2 ± 4.7	167.6 ± 2.6	21.1 ± 1.7	38.7 ± 6.9
		<b>*34 ± 8</b>	<b>66.7 ± 10.9</b>	<b>171.6 ± 6.3</b>	<b>22.5 ± 2.4</b>	<b>41.2 ± 6.8</b>
	Total (N=16)	<b>30 ± 8</b>	<b>67.7 ± 13.0</b>	<b>172.0 ± 8.4</b>	<b>22.7 ± 2.6</b>	<b>41.5 ± 6.8</b>

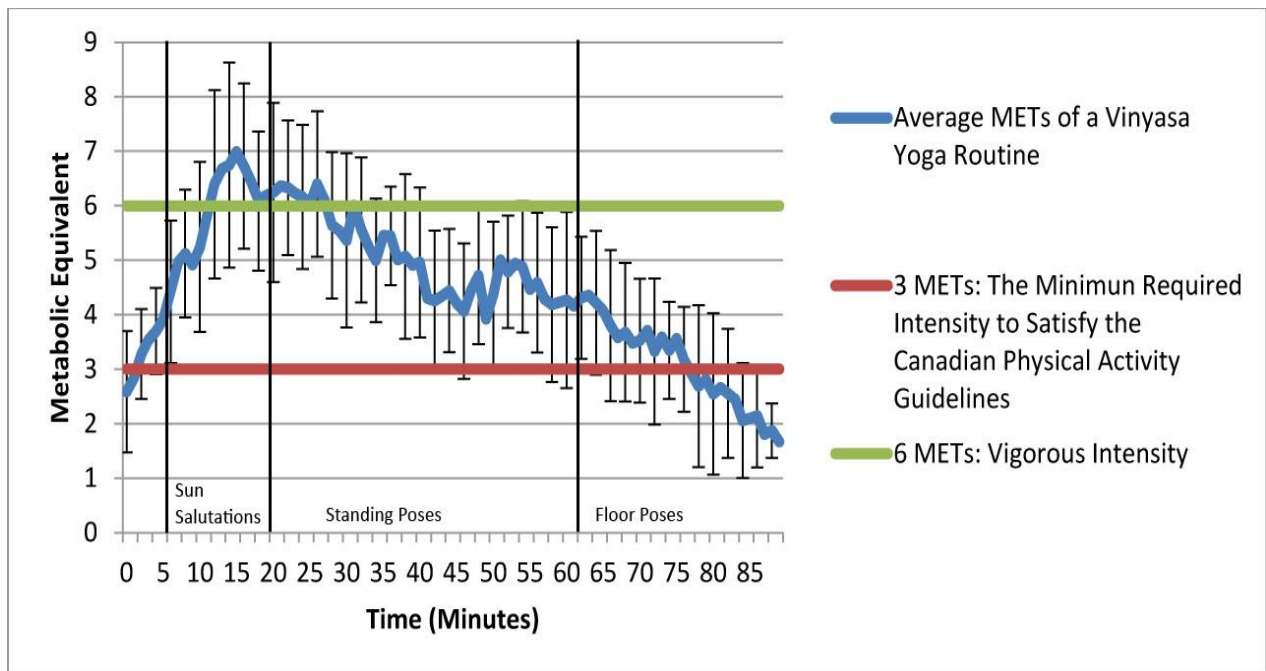
**Table 3.1 Participant Characteristics**

Participant characteristics are displayed in means and standard deviations, BMI = Body mass index, VO<sub>2</sub> max = maximum oxygen consumption. \* Significantly different from beginner group ( $p = 0.02$ ).

### 3.2 Absolute Measures

The total energy expenditure for a Vinyasa yoga routine was  $451 \pm 146$  kcal with an average of  $5.9 \pm 1.7$  kcal/min. The intensity was  $4.7 \pm 1.0$  METs and the participants were working at  $40.2 \pm 7.1$  %,  $34.5 \pm 13.2$  %,  $52.3 \pm 7.0$  %, and  $27.1 \pm 9.9$  % of their maximum oxygen consumption,  $\text{VO}_2$  reserve, maximum heart rate and heart rate reserve, respectively. The relative oxygen consumption was  $16.5 \pm 5.3$  mL/min/kg. On the 10-point Borg Scale, the participants on average were working at  $4.4 \pm 1.4$  or a “strong” effort.

The mean METs of Vinyasa yoga ( $4.7 \pm 1.0$ ) was significantly higher ( $t(71) = 9.65$ ,  $p < 0.001$ ) than the 3.0 METs needed to achieve a moderate intensity based on the Canadian Physical Activity Guidelines. During the yoga session,  $68 \text{ minutes} \pm 10$  were spent above 3.0 METs (moderate intensity) and of those minutes,  $16 \pm 16$  were spent above 6.0 METs (vigorous intensity). Figure 3.1 displays the distribution of METs throughout the Vinyasa yoga session.



**Figure 3.1 MET Distribution During a Vinyasa Yoga Routine**

The distribution of the MET means in a Vinyasa yoga session in comparison to 3 METs (moderate intensity), the minimum required to satisfy the Canadian Physical Activity Guidelines and 6 METs (vigorous intensity). Mean values of each time point are displayed with standard deviation error bars.

### **3.3 Comparing Relative Differences between Beginner and Advanced Practitioners**

Results across all time points are presented for the beginner versus advanced practitioners in Table 3.2 and for males versus females in Table 3.3. No 3-way interactions (i.e. skill level  $\times$  sex  $\times$  time) in the beginner routine were apparent; therefore, only 2-way interactions (i.e. skill level  $\times$  time, sex  $\times$  time) and main effects are presented.

	Sun Salutations		Standing Poses		Floor Poses	
	Beginner	Advanced	Beginner	Advanced	Beginner	Advanced
METs <sup>#</sup>	5.8 ± 1.0	5.7 ± 1.5	4.9 ± 0.9	4.6 ± 1.0	3.3 ± 0.8	3.0 ± 0.8
kcal/min <sup>#</sup>	6.9 ± 2.5	6.5 ± 2.2	6.0 ± 2.2	5.3 ± 1.5	4.2 ± 1.5	3.4 ± 1.1
%VO <sub>2</sub> max <sup>#</sup>	48.9 ± 7.8	48.8 ± 10.0	41.6 ± 7.1	39.3 ± 5.5	27.3 ± 7.9	25.4 ± 4.4
%VO <sub>2</sub> R <sup>#</sup>	44.1 ± 8.1	43.9 ± 10.8	36.2 ± 7.3	33.5 ± 6.0	20.5 ± 7.8	18.3 ± 4.9
%MHR <sup>§</sup>	53.9 ± 9.4	51.6 ± 5.3	58.4 ± 10.9	53.4 ± 7.2	46.8 ± 10.1	43.1 ± 6.6
%HRR <sup>§</sup>	29.7 ± 14.2	25.3 ± 6.8	37.5 ± 14.4	27.9 ± 8.7	26.0 ± 11.5	11.7 ± 8.0
RPE	4.3 ± 1.6	3.5 ± 1.0	4.9 ± 1.9	3.4 ± 0.9	4.7 ± 2.0	3.7 ± 1.3
VE <sup>§</sup>	27.4 ± 9.9	23.5 ± 8.8	29.3 ± 11.5	23.0 ± 6.8	20.9 ± 7.0	16.4 ± 6.9
VT <sup>#</sup>	1.6 ± 0.8	2.0 ± 0.8	1.2 ± 0.5	1.6 ± 0.6	1.0 ± 0.5	1.1 ± 0.5
RF <sup>§ ∞</sup>	19.5 ± 6.6	13.3 ± 5.2	25.5 ± 6.0	16.8 ± 4.7	22.6 ± 4.3	16.7 ± 3.2
VE/VO <sub>2</sub> <sup>∞</sup>	19.3 ± 1.7	17.2 ± 1.5	23.8 ± 2.4	21.1 ± 1.7	24.6 ± 2.1	23.0 ± 3.3
VE/VCO <sub>2</sub>	24.1 ± 2.8	22.7 ± 2.4	27.7 ± 2.5	25.8 ± 2.5	29.3 ± 3.0	28.2 ± 4.9

**Table 3.2 Means and Standard Deviations of Beginner and Advanced Practitioners Completing a Beginner Routine.**

MET (Metabolic Equivalent), kcal/min (kilocalories/minute), %VO<sub>2</sub>max (percentage of max oxygen uptake), %MHR (percentage of maximal heart rate), %HRR (percentage of heart rate reserve), RPE (rating of perceived exertion), VE (minute ventilation, L/min), VT (tidal volume, L), Rf (breathing frequency, breaths/min), VE/VO<sub>2</sub> (ventilatory equivalent for oxygen), VE/VCO<sub>2</sub> (ventilatory equivalent for carbon dioxide) . No group by time interactions were present in any of the measures. There was a time main effect for all measures except RPE. # Indicates a significant difference between all time points ( $p < 0.01$ ). § Indicates that floor poses were significantly different from sun salutations and standing ( $p < 0.01$ ). ∞ Indicates a main group effect with the beginner group being significantly higher than the advanced group,  $p < 0.05$ .



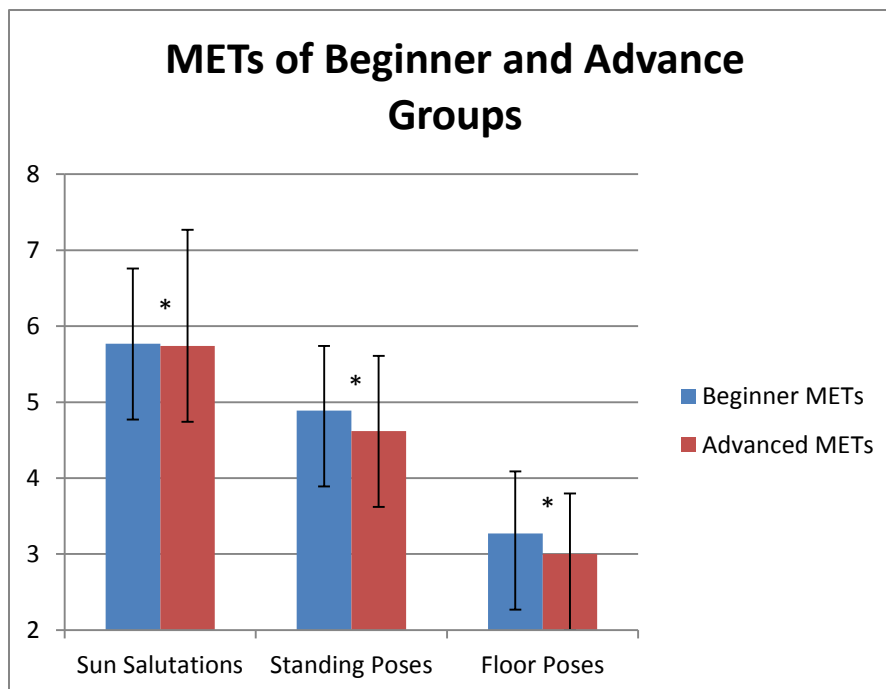
	Sun Salutations		Standing Poses		Floor Poses	
	Males	Females	Males	Females	Males	Females
METs	*6.6 ± 1.1	4.9 ± 0.7	*5.4 ± 0.8	4.2 ± 0.6	*3.7 ± 0.7	2.6 ± 0.5
kcal/min	*8.6 ± 1.4	4.7 ± 1.0	*7.1 ± 1.3	4.2 ± 0.9	*4.8 ± 0.9	2.8 ± 0.6
%VO <sub>2</sub> max	52.4 ± 9.0	45.3 ± 7.5	42.1 ± 6.7	38.8 ± 5.6	26.8 ± 7.3	26.0 ± 5.4
%VO <sub>2</sub> R	48.3 ± 9.1	39.7 ± 7.6	37.1 ± 7.0	32.5 ± 5.6	20.4 ± 4.7	18.4 ± 5.2
%MHR	55.0 ± 8.3	50.5 ± 6.3	59.1 ± 8.7	52.6 ± 9.2	49.6 ± 7.8	40.3 ± 6.5
%HRR	29.2 ± 13.6	25.8 ± 8.2	35.1 ± 14.7	30.3 ± 10.5	20.3 ± 14.5	17.4 ± 9.9
RPE	4.1 ± 1.0	3.7 ± 1.7	4.4 ± 1.9	3.9 ± 1.4	4.6 ± 2.2	3.8 ± 1.0
VE	28.7 ± 10.6	22.2 ± 7.0	28.9 ± 11.9	23.3 ± 6.4	20.4 ± 7.7	16.9 ± 6.5
VT	*2.4 ± 0.8	1.3 ± 0.4	*1.8 ± 0.5	1.0 ± 0.3	*1.3 ± 0.5	0.8 ± 0.2
RF	16.2 ± 6.9	16.7 ± 6.7	20.6 ± 6.8	21.7 ± 7.3	20.0 ± 5.0	19.3 ± 4.8
VE/VO <sub>2</sub>	17.9 ± 1.6	18.5 ± 2.2	22.1 ± 2.4	22.9 ± 2.6	23.9 ± 2.9	23.7 ± 2.9
VE/VCO <sub>2</sub>	22.9 ± 2.9	23.9 ± 2.4	26.0 ± 2.8	27.4 ± 2.7	28.7 ± 3.8	28.9 ± 4.4

**Table 3.3 Means and Standard Deviations of Male and Females Practitioners Completing a Beginner Routine**

\*Significantly different from females at that time point. See above table for time main effects.

### 3.3.1 Metabolic Equivalent

Sphericity was not met so a Greenhouse-Geisser epsilon was used to adjust the degrees of freedom. There was no significant skill group x time interaction in METs,  $F(1.39, 24) = 0.645$ ,  $p = 0.483$ ,  $\eta_p^2 = 0.051$ . A significant sex x time interaction was found,  $F(1.39, 24) = 4.39$ ,  $p = 0.041$ ,  $\eta_p^2 = 0.268$ . Further investigation with independent t-tests showed a significant difference between men and women during the sun salutations  $t(14) = 3.82$ ,  $p = 0.002$ , standing poses  $t(14) = 3.54$ ,  $p = 0.003$ , and the floor poses  $t(14) = 3.52$ ,  $p = 0.003$ , with men higher at each time point. No main effect for group was present,  $F(1, 24) = 0.282$ ,  $p = 0.605$ ,  $\eta_p^2 = 0.023$ . See Figure 3.2.



**Figure 3.2 METs During Beginner Routine**

Mean MET values during the beginner routine for the beginner and advanced groups. There were no significant differences between groups but all time points were significantly different from each other ( $p < 0.01$ ) which is signified by \*.

### 3.3.2 kcal/Minute

Sphericity was not met so a Greenhouse-Geisser adjustment was used. No significant skill group x time interaction for kcal/minute was discovered,  $F(1.30,24) = 0.718, p = 0.445, \eta_p^2 = 0.056$ . There was a significant sex x time interaction,  $F(1.30,24) = 17.1, p < 0.001, \eta_p^2 = 0.587$ . Further investigation showed a significant difference between males and females during the sun salutations  $t(14) = 6.32, p < 0.001$ , standing poses  $t(14) = 5.24, p < 0.001$ , and floor poses  $t(14) = 5.28, p < 0.001$ , with men higher at each time point. There was no significant differences between skill groups,  $F(1,24) = 1.53, p = 0.240, \eta_p^2 = 0.113$ .

### 3.3.3 Percentage of VO<sub>2</sub> Max

Sphericity was not met so a Greenhouse-Geisser epsilon was used to adjust the degrees of freedom. Percentage of VO<sub>2</sub> produced no significant skill group x time interaction,  $F(1.18,24) = 0.384, p = 0.579, \eta_p^2 = 0.03$  nor was there a significant sex x time interaction,  $F(1.18,24) = 2.72, p = 0.117, \eta_p^2 = 0.185$ . There was a time main effect,  $F(1.18,24) = 137.0, p < 0.001, \eta_p^2 = 0.919$ . A Bonferroni post-hoc test revealed that percentage of VO<sub>2</sub> max was significantly different between all time points ( $p < 0.001$ ) with sun salutations eliciting the highest percent VO<sub>2</sub> max and the floor poses having the lowest. No significant difference between beginners and advanced practitioners were found,  $F(1,24) = 0.197, p = 0.665, \eta_p^2 = 0.016$  nor were there any differences between males and females,  $F(1,24) = 1.40, p = 0.260, \eta_p^2 = 0.105$ .

### 3.3.4 Percentage of VO<sub>2</sub> Reserve

Sphericity was not met so a Greenhouse-Geisser adjustment was used. No significant skill group x time interaction was evident for percent of VO<sub>2</sub>R,  $F(1.17,24) = 0.392, p = 0.574, \eta_p^2 = 0.032$  nor was there a sex x time interaction,  $F(1.17,24) = 2.44, p = 0.138, \eta_p^2 = 0.169$ . There was a time main effect for percent VO<sub>2</sub>R,  $F(1.17,24) = 136.6, p < 0.001, \eta_p^2 = 0.919$  and a

Bonferroni post-hoc test revealed a significant difference between all time points ( $p < 0.001$ ) with the sun salutations having the highest percent  $\text{VO}_2\text{R}$  and the floor poses having the lowest. A main effect for skill group was not present,  $F(1,24) = 0.270$ ,  $p = 0.613$ ,  $\eta_p^2 = 0.022$  or for sex,  $F(1,24) = 2.52$ ,  $p = 0.138$ ,  $\eta_p^2 = 0.174$ .

### 3.3.5 Parentage of Maximum Heart Rate

No skill group x time interaction for percentage of max heart rate was found,  $F(2,24) = 0.360$ ,  $p = 0.702$ ,  $\eta_p^2 = 0.29$  nor was there a significant sex x time interaction,  $F(2,24) = 1.14$ ,  $p = 0.336$ ,  $\eta_p^2 = 0.087$ . There was a time main effect for percentage of max heart rate,  $F(2,24) = 24.2$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.668$ . A Bonferroni post-hoc demonstrated there was no significant difference between the sun salutations and the standing poses ( $p = 0.07$ ) but that both of those sections were significantly higher than the floor section ( $p < 0.01$ ). No significant differences were discovered between beginner and advanced groups,  $F(1,24) = 1.00$ ,  $p = 0.337$ ,  $\eta_p^2 = 0.077$  or between males and females,  $F(1,24) = 3.51$ ,  $p = 0.085$ ,  $\eta_p^2 = 0.0277$ .

### 3.3.6 Percentage of Heart Rate Reserve

There was no significant group x time interaction,  $F(2,24) = 2.54$ ,  $p = 0.10$ ,  $\eta_p^2 = 0.174$  and no sex x time interaction for percentage of heart rate,  $F(2,24) = 0.091$ ,  $p = 0.913$ ,  $\eta_p^2 = 0.008$ . A time main effect was discovered,  $F(2,24) = 19.9$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.624$  and a Bonferroni post-hoc revealed a trend for the standing poses to be higher than the sun salutations ( $p=0.053$ ) in percentage of heart rate reserve. Both the sun salutations and the standing poses were higher in percent heart rate reserve than the floor poses ( $p = 0.013$  and  $p < 0.001$ , respectively). There was no main effect for group,  $F(1,24) = 3.25$ ,  $p = 0.096$ ,  $\eta_p^2 = 0.213$  nor for sex,  $F(1,24) = 0.501$ ,  $p = 0.492$ ,  $\eta_p^2 = 0.040$ .

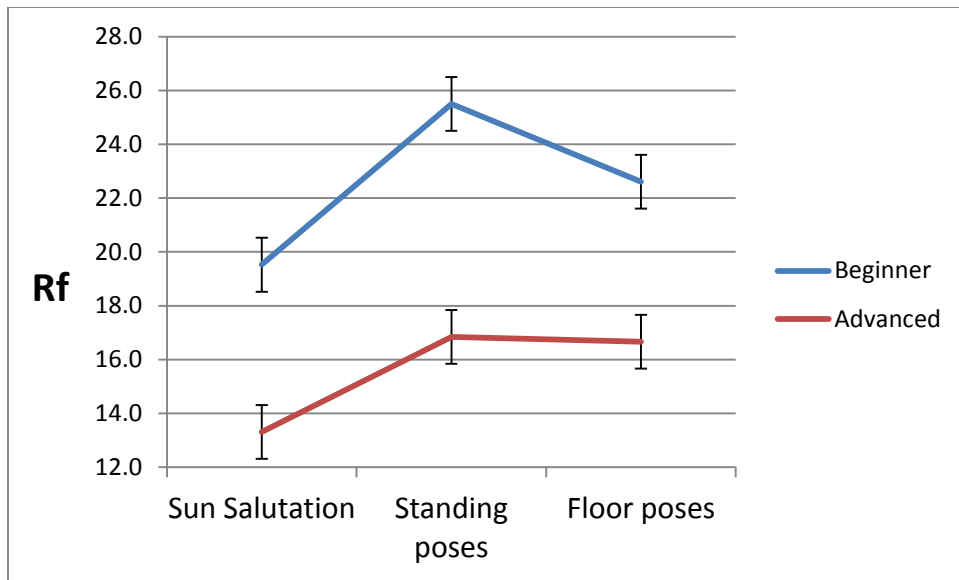
### 3.3.7 Rating of Perceived Exertion

No significant group x time interaction was demonstrated,  $F(2,24) = 0.244, p = 0.785, \eta_p^2 = 0.049$  as well as no sex x time interaction,  $F(2,24) = 0.059, p = 0.943, \eta_p^2 = 0.009$  for RPE. A time main effect for RPE was not present,  $F(2,24) = 0.217, p = 0.807, \eta_p^2 = 0.018$ . There was also no main effect for group,  $F(1,24) = 3.36, p = 0.092, \eta_p^2 = 0.219$  nor was there a main effect for sex,  $F(1,24) = 0.945, p = 0.35, \eta_p^2 = 0.073$

### 3.3.8 Respiratory Measures

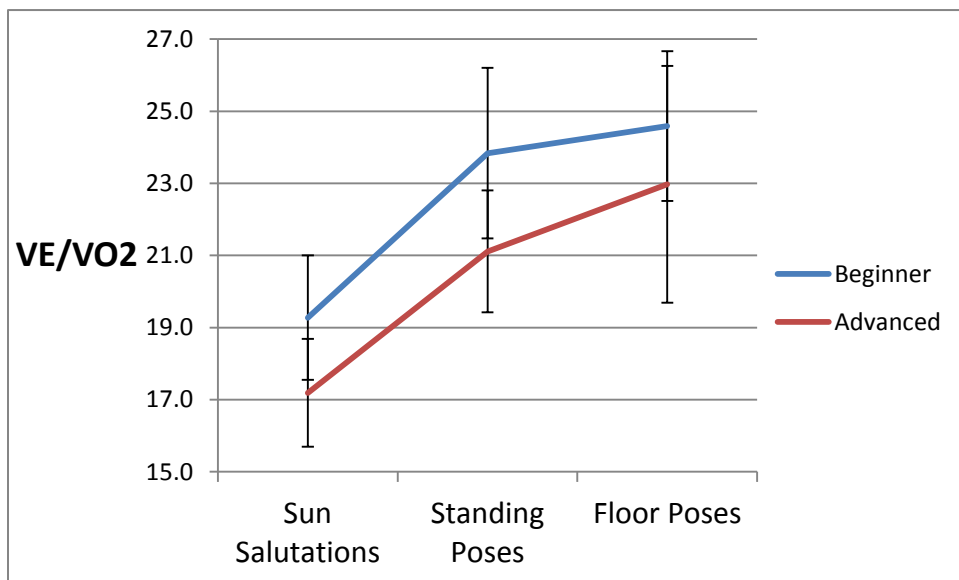
Sphericity was not met for VT and VE/VCO<sub>2</sub> so Greenhouse-Geisser adjustments in the degrees of freedom were made. There were no significance group x time interactions in minute ventilation (VE), breathing frequency (Rf), tidal volume (Vt), VE/VO<sub>2</sub>, or VE/VCO<sub>2</sub>,  $p > 0.05$ . There was a significant sex by time interaction for Vt,  $F(2,24) = 2.61, p = 0.012, \eta_p^2 = 0.309$ . Further *t*-tests showed a significant difference between males and females during the sun salutations  $t(14) = 3.64, p = 0.004$ , standing poses  $t(14) = 3.94, p = 0.002$ , and floor poses  $t(14) = 3.19, p = 0.007$ , with men higher at all time points. No significant sex x time interactions were found for VE, Rf, VE/VO<sub>2</sub>, or VE/VCO<sub>2</sub>,  $p > 0.05$

There was a group main effect for Rf,  $F(1,24) = 7.24, p = 0.02, \eta_p^2 = 0.695$  demonstrating that beginners were significantly higher than advanced practitioners. There was also a group main effect for VE/VO<sub>2</sub>,  $F(1,24) = 4.92, p = 0.047, \eta_p^2 = 0.532$  with beginners being significantly higher than advanced practitioners.



**Figure 3.4 Breathing Frequency Group Main Effect**

Beginner group was significantly higher than advanced group,  $p = 0.02$ .



**Figure 3.5 Ventilatory Equivalent for O<sub>2</sub> Group Main Effect**

Beginner group was significantly higher than advanced group,  $p = 0.047$

### **3.4 Comparing Absolute Differences Between Beginner and Advanced Practitioners**

Results across all time points are presented for the beginner vs. advanced practitioners in Table 3.4 and for males vs. females in Table 3.5. For the sections below, statistical results for significant interactions and main effects are described. There were no 3-way interactions (i.e. skill level  $\times$  sex  $\times$  time); therefore, only 2-way interactions and main effects are presented.

	Sun Salutations		Standing Poses		Floor Poses	
	Beginner	Advanced	Beginner	Advanced	Beginner	Advanced
METs <sup>#</sup>	5.8 ± 1.0	6.4 ± 1.0	4.9 ± 0.9	5.5 ± 1.1	3.3 ± 0.8	3.4 ± 1.0
kcal/min <sup>#</sup>	6.9 ± 2.5	7.2 ± 1.8	6.0 ± 2.2	6.2 ± 1.5	4.2 ± 1.5	3.9 ± 1.3
%VO <sub>2</sub> max <sup>#</sup>	48.9 ± 7.8	54.6 ± 7.9	41.6 ± 7.1	46.7 ± 7.1	27.3 ± 7.9	29.0 ± 6.0
%VO <sub>2</sub> R <sup>#</sup>	44.0 ± 8.1	50.3 ± 8.3	36.2 ± 7.3	41.6 ± 7.6	20.5 ± 7.8	22.2 ± 6.8
%MHR <sup>#</sup>	53.9 ± 9.4	55.3 ± 4.1	58.4 ± 10.9	61.6 ± 4.2	46.8 ± 10.1	46.6 ± 5.6
%HRR* <sup>#</sup>	29.7 ± 14.2	29.8 ± 7.7	37.5 ± 14.4	39.9 ± 8.5	26.0 ± 11.5	16.4 ± 8.9
RPE	4.3 ± 1.6	5.1 ± 1.5	4.9 ± 1.9	5.3 ± 1.3	4.7 ± 2.0	4.6 ± 1.3
VE <sup>#</sup>	27.4 ± 9.9	28.4 ± 8.2	29.3 ± 11.5	30.1 ± 8.6	20.9 ± 7.0	20.0 ± 7.4
VT <sup>#</sup>	1.6 ± 0.8	2.0 ± 0.6	1.2 ± 0.5	1.5 ± 0.4	1.0 ± 0.5	1.1 ± 0.3
RF <sup>#</sup>	19.5 ± 6.6	15.8 ± 5.4	25.5 ± 6.0	21.6 ± 5.6	22.6 ± 4.3	19.2 ± 4.2

**Table 3.4 Means for Beginner and Advanced practitioners Completing a Skill-appropriate Routine**

Means and standard deviations of beginner and advanced practitioners at appropriate skill level. \* Significant group by time interaction. See text for explanation of the interaction. There was a time main effect for all measures. # Denotes a significant difference between all time points ( $p < 0.05$ ).



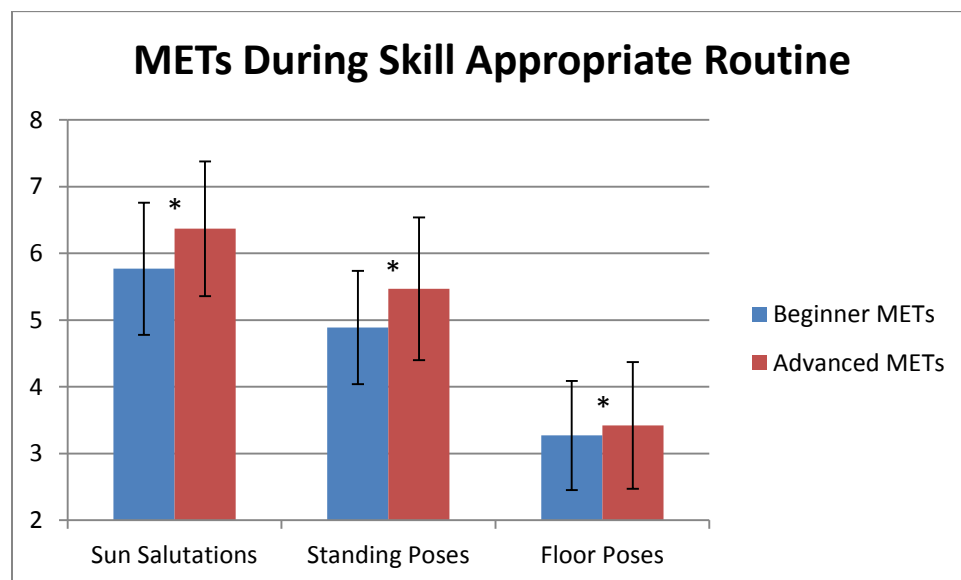
	Sun Salutations		Standing Poses		Floor Poses	
	Males	Females	Males	Females	Males	Females
METs	6.7 ± 0.9	5.5 ± 0.8	5.7 ± 1.0	4.7 ± 0.7	3.9 ± 0.8	2.8 ± 0.6
kcal/min	*8.7 ± 1.5	5.4 ± 1.1	*7.5 ± 1.3	4.7 ± 0.9	*5.1 ± 0.9	2.9 ± 0.6
%VO <sub>2</sub> max	52.8 ± 8.1	50.7 ± 8.6	44.6 ± 7.8	43.7 ± 7.4	28.5 ± 8.6	27.8 ± 5.1
%VO <sub>2</sub> R	48.7 ± 8.5	45.7 ± 9.0	39.9 ± 8.2	37.9 ± 7.6	22.4 ± 9.1	20.4 ± 4.9
%MHR	55.5 ± 8.0	53.6 ± 6.3	61.6 ± 8.2	58.4 ± 8.2	51.3 ± 6.8	42.1 ± 6.2
%HRR	29.5 ± 13.3	30.0 ± 9.0	39.3 ± 13.5	38.1 ± 10.1	23.1 ± 13.0	19.3 ± 9.3
RPE	4.7 ± 1.4	4.7 ± 1.8	5.5 ± 2.0	4.7 ± 1.0	5.1 ± 2.2	4.3 ± 0.7
VE	34.3 ± 7.2	21.5 ± 4.7	36.6 ± 8.8	22.8 ± 4.5	25.9 ± 5.3	14.9 ± 2.5
VT	2.2 ± 0.7	1.4 ± 0.5	1.7 ± 0.4	1.1 ± 0.3	1.3 ± 0.3	0.9 ± 0.3
RF	17.7 ± 6.3	17.7 ± 6.4	23.6 ± 5.2	23.5 ± 7.0	22.1 ± 4.2	19.7 ± 4.6

**Table 3.5 Means for Male and Female Practitioners Completing a Skill-appropriate Routine**

Means and standard deviations of male and female practitioners at appropriate skill level. \* Significantly different from females at same time point. See above table for time main effects.

### 3.4.1 METs

There was no significant skill group x time interaction for METs,  $F(2,24) = 1.72, p = 0.201, \eta_p^2 = 0.125$  as well as no significant sex x time interaction,  $F(2,24) = 0.189, p = 0.829, \eta_p^2 = 0.016$ . There was a time main effect for METs,  $F(2,24) = 213.8, p < 0.001, \eta_p^2 = 0.947$ . Further post-hoc tests revealed that all 3 time points are significantly different from one another ( $p < 0.001$ ) with sun salutation being the highest in METs and floor poses being the lowest. No main effect for group was discovered,  $F(1,24) = 1.36, p = 0.266, \eta_p^2 = 0.102$  but there was a main effect for sex,  $F(1,24) = 8.16, p = 0.014, \eta_p^2 = 0.405$  with the males being significantly higher than females.



**Figure 3.6 METs During Skill Appropriate Routine**

Mean METS values during the skill appropriate routine for the beginner and advanced groups. There were no significant differences between the beginner and advanced groups. \* Denotes all time points were significantly different from one another ( $p < 0.05$ ).

### 3.4.2 kcal/Minute

Sphericity was not met so a Greenhouse Geisser epsilon was used to adjust the degrees of freedom. There was no significant skill group x time interaction,  $F(1.37, 24) = 1.51, p = 0.245, \eta_p^2 = 0.112$ . A sex by time interaction was revealed,  $F(1.37, 24) = 5.49, p = 0.023, \eta_p^2 = 0.314$ . Males expended significantly higher kcal/min than females during sun salutations  $t(14) = 5.11, p < 0.001$ , standing poses  $t(14) = 5.06, p < 0.001$ , and floor poses  $t(14) = 5.66, p < 0.001$ . No significant difference were found between beginner and advanced practitioners,  $F(1, 24) = 0.033, p = 0.859, \eta_p^2 = 0.003$ .

### 3.4.3 Percentage of VO<sub>2</sub> Max

A Greenhouse-Geisser adjustment was used since sphericity was not met. No significant skill group x time interaction in percentage of VO<sub>2</sub> max was apparent,  $F(1.37, 24) = 0.930, p = 0.380, \eta_p^2 = 0.072$  nor was there a sex x time interaction,  $F(1.37, 24) = 0.096, p = 0.835, \eta_p^2 = 0.008$ . There was a time main effect,  $F(1.37, 24) = 112.3, p < 0.001, \eta_p^2 = 0.903$  and a Bonferroni post-hoc test revealed that all time points were significantly different from one another ( $p < 0.001$ ). Sun salutations demonstrated the highest percentage of VO<sub>2</sub> max whereas the floor poses demonstrated the lowest. There was no significant difference between beginner and advanced practitioners,  $F(1, 24) = 1.51, p = 0.243, \eta_p^2 = .111$ , as well as no significant differences between males and females,  $F(1, 24) = 0.137, p = 0.718, \eta_p^2 = 0.011$ .

### 3.4.4 Percentage of VO<sub>2</sub> Reserve

Sphericity was not met so a Greenhouse-Geisser adjustment was used. Percent of VO<sub>2</sub>R demonstrated no skill group x time interaction,  $F(1.36, 24) = 0.955, p = 0.372, \eta_p^2 = 0.074$  nor was a sex time interaction shown,  $F(1.36, 24) = 0.058, p = 0.882, \eta_p^2 = 0.005$ . A time main effect for percent VO<sub>2</sub>R was discovered,  $F(1.36, 24) = 110.2, p < 0.001, \eta_p^2 = 0.902$  and a Bonferroni

post-hoc test revealed a significant difference between all time points ( $p < 0.001$ ) with the sun salutations having the highest percent  $\text{VO}_2\text{R}$  and the floor poses have the lowest. There was no main effect for group,  $F(1,24) = 1.68, p = 0.219, \eta_p^2 = .0123$  nor was there a main effect for sex,  $F(1,24) = 0.44, p = 0.518, \eta_p^2 = 0.0173$ .

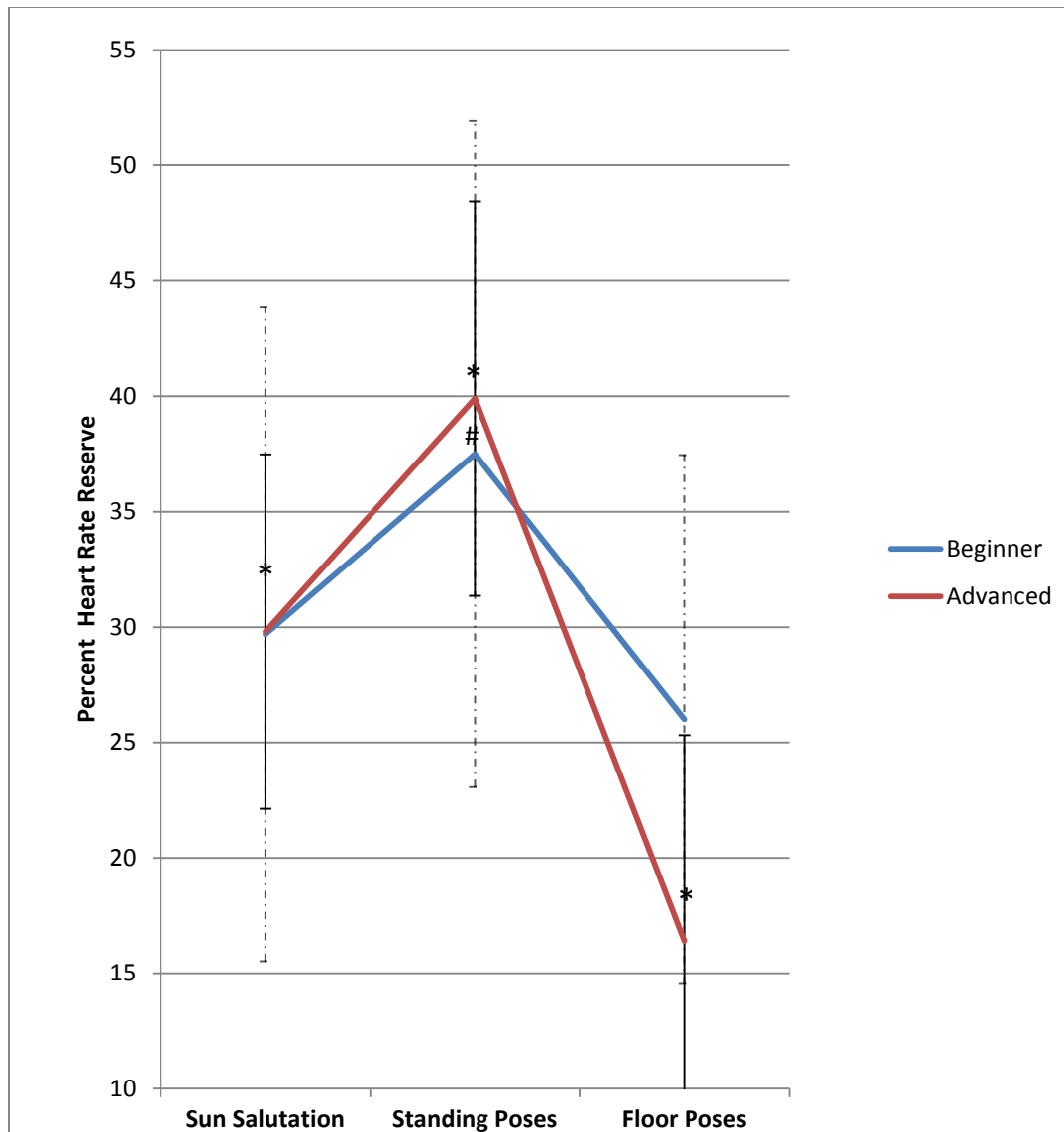
### 3.4.5 Percentage of Maximum Heart Rate

No significant skill group x time interaction was demonstrated,  $F(2,24) = 0.524, p = 0.599, \eta_p^2 = 0.042$  nor was there a sex x time interaction for percentage of maximal heart rate  $F(2,24) = 2.716, p = 0.086, \eta_p^2 = 0.185$ . There was a time main effect for percentage of max heart rate,  $F(2,24) = 32.8, p < 0.001, \eta_p^2 = 0.732$ . Further investigation with post-hoc tests revealed that all time points were significantly different from each other ( $p < 0.01$ ). The standing poses elicited the highest percent max heart rate followed by the sun salutations. The floor poses displayed the lowest percentage of max heart rate. There was no main effect for group,  $F(1,24) = 0.198, p = 0.664, \eta_p^2 = 0.016$  as well as no main effect for sex,  $F(1,24) = 1.99, p = 0.184, \eta_p^2 = 0.142$ .

### 3.4.6 Percentage of Heart Rate Reserve

A significant group by time interaction was apparent for percentage of heart rate reserve,  $F(2,24) = 3.95, p = 0.033, \eta_p^2 = 0.274$ , indicating a difference in beginner and advanced practitioners' mean % HRR across the 3 time points. There were no significant differences between groups at any time points,  $F(1,24) = 0.202, p = 0.661, \eta_p^2 = 0.017$ . To explain the group x time interaction, dependent t-tests were run across time points within each group and a Bonferroni adjustment was used (making significance  $p < 0.017$ ). For the beginner group, the standing poses were significantly higher than the floor poses,  $t(7) = 3.20, p = 0.015$  but no significant difference between the standing poses and the sun salutations were evident,  $t(7) =$

2.36,  $p = 0.052$ . There was also no difference between the sun salutations and the floor poses,  $t(7) = 0.846$ ,  $p = 0.426$ . For the advanced group, significant differences were found between all the time points with floor poses being the lowest, followed by sun salutations, and standing poses ( $p < 0.004$ ). There was no sex x time interaction,  $F(2,24) = 0.426$ ,  $p = 0.658$ ,  $\eta_p^2 = 0.034$ . Percent of HRR between males and females were not different,  $F(1,24) = 0.081$ ,  $p = 0.781$ ,  $\eta_p^2 = 0.007$ . See figure 3.4 for group by time interaction



**Figure 3.7 Group by time interaction for % HRR**

# Denotes the beginner standing poses are significantly different from the beginner floor poses ( $p = 0.015$ ). \* Signifies all the advanced times points were significantly different from one another ( $p < 0.004$ )

### 3.4.7 Rating of Perceived Exertion

The skill group x time interaction for rating of perceived exertion was not significant,  $F(2,24) = 0.381, p = 0.687, \eta_p^2 = 0.031$ . There was also no significant sex x time interaction,  $F(2,24) = 0.515, p = 0.604, \eta_p^2 = 0.041$ . No main effect for time was demonstrated for RPE,  $F(2,24) = 0.516, p = 0.603, \eta_p^2 = 0.041$ . There was no significant differences between skill groups,  $F(1,24) = 0.312, p = 0.587, \eta_p^2 = 0.025$  nor sexes,  $F(1,24) = 0.656, p = 0.434, \eta_p^2 = 0.052$ .

### 3.4.8 Respiratory Measures

Sphericity was not met for VT so a Greenhouse-Geisser adjustment was used. There were no significant sex x time interactions for VE, Rf, VE/VO<sub>2</sub>, and VE/VCO<sub>2</sub>,  $p > 0.05$ . Males tended to respond differently than females over the time points in VT, but this just missed reaching statistical significance,  $F(1,24) = 3.92, p = 0.053, \eta_p^2 = 0.053$ . No significant group x time interactions were found for VT, VE, Rf, VE/VO<sub>2</sub>, and VE/VCO<sub>2</sub>,  $p > 0.05$ . There were no main effects for group,  $p > 0.05$ .

### **3.5 Post- Hoc Sample Size Calculation**

A post-hoc sample size calculation was carried out using GPower® Version 3. Mean METs from the beginner and advanced groups were used since this is of interest to explore the second hypothesis. When the sample size calculation was carried out using the values from the skill appropriate routine, with a power of 80 % and an alpha level of 0.05, it was determined that 14 participants would be needed per skill group. Using the values from the different skill groups completing the same beginner routine, with a power of 80 % and an alpha level of  $p = 0.05$ , it was determined that 32 participants per skill group were needed.



## CHAPTER 4 DISCUSSION

### 4.1 The Intensity of Vinyasa Yoga

The findings of my research demonstrated that over a wide range of skill levels, Vinyasa yoga met the criteria of moderate to vigorous intensity to achieve health benefits according to the Canadian Physical Activity Guidelines. The guidelines state, “to achieve health benefits, adults aged 18-64 years should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more” (CSEP, 2014). Moderate intensity is described as 3.0 – 5.9 METs and vigorous intensity is > 6.0 METs. Across all groups (beginner and advanced) and for both males and females, on average  $68 \pm 10$  minutes were spent above 3.0 MET and of those minutes,  $16 \pm 16$  were spent above 6.0 MET. As hypothesized a 90-minutes vinyasa yoga routine satisfied the recommended 150 minutes of physical activity at a moderate – vigorous intensity if completed 2 to 3 times per week.

According to the Canadian Health Measures Survey completed from 2007 to 2009, only 15.4% of adults (17% men and 14% women) met the recommendations of the Canadian Physical activity guidelines (Colley et al., 2011). Vinyasa yoga can be an additional method to help adults meet these recommendations. Vinyasa yoga gives those adults who do not prefer conventional types of exercise like walking, running or biking an alternative option to still achieve health benefits.

To give the reader an understanding of what 4.7 METs feels like in terms of intensity it could be compared to a very brisk walk. Table 4.1 displays common exercises that are ranked around a similar MET value (Ainsworth et al., 2011).

<b>METs</b>	<b>Activity</b>
<b>4.0</b>	Tai Chi (Li et al., 2001)
<b>4.5</b>	Calisthenics, light or moderate effort, getting up and down from the floor
<b>4.5</b>	Basket Ball, shooting baskets
<b>4.5</b>	Tennis, Doubles
<b>4.5</b>	Golf, walking and carrying clubs
<b>4.7</b>	<b>Vinyasa Yoga (current study findings)</b>
<b>4.8</b>	Tap dancing
<b>4.8</b>	Stationary rowing, moderate effort
<b>4.8</b>	Swimming, backstroke, recreational
<b>5.0</b>	Ballet, modern or jazz, general, rehearsal class
<b>5.0</b>	Walking and carrying objects 25 to 49 lbs.
<b>5.0</b>	Walking, 4.0 mph, level, firm surface, very brisk pace
<b>5.0</b>	Walk/run, playing with animals, vigorous
<b>5.3</b>	Water aerobics/ water calisthenics
<b>5.3</b>	Downhill skiing, moderate effort
<b>5.3</b>	Snow shoeing, Moderate effort

**Table 4.1 METs of Common Activities that are Similar to Vinyasa Yoga.**

All values were derived from the 2011 Compendium of Physical Activities: A Second Update of Codes and MET Values (Ainsworth et al.) unless otherwise specified.

#### **4.4.1 Energy Expenditure of Similar Exercise Modalities**

It could prove useful to determine the energy expenditure of other forms of similar alternative exercise modalities. Pilates, which is performed on a mat, holds some similarities to the floor portion of the yoga routine; however, limited research has been carried out on the

metabolic demands and energy expenditure of Pilates. Methods similar to this study could be used in future research to determine these unknown factors in Pilates.

Tai Chi, being a series of slow movements with body weight only would be expected to have similar energy expenditure. There are different types of Tai Chi just like there are differently types of yoga and as expected there is a range of energy expenditures. A review that investigated the physiological characteristics of Tai Chi obtained a range from 2.5 – 6.5 METs for different types of Tai Chi (Li, Hong, & Chan, 2001). As expected, the more vigorous types of Tai Chi as well as the lower positioning of the poses (more of a bend in the knees) elicited higher energy expenditure. The overall average for all forms of Tai Chi was about 4 METs. This is lower than what was found in the current study with Vinyasa yoga where the average METs was 4.7. Since all forms for Tai Chi were used in the mean calculation it is expected that the energy expenditure would be lower to account for the mild to moderate energy expenditure in certain forms of Tia Chi. If the energy expenditure of all forms of yoga were average together the values would also be lower than in the current study.

Since Vinyasa yoga involved movements like lunges, planks and low push-up positions it resembles calisthenics. Limited research has been carried out on calisthenics involving squats, lunges, push-ups but Greer et al. (1980) showed that basic calisthenics movements (i.e. standing hip flexion and extension, trunk rotations, lateral side bends, arm circles and standing knee raises) had average MET values ranging from 2.0 to 4.5. The averange range in the current study was 3.1 to 6.4. This could have been higher due to the recruitment of larger muscle groups in the lower legs as well as partial weight bearing with the upper body. A study investigating upper and lower body calisthenics determined the METs range to be 2.1 to 6.4 (Cassady & Nielsen, 1992). This is a large range and is dependent on the use of upper and lower body activation. During the

sun salutation in Vinyasa yoga there is more of a combination of upper and lower body activation with a portion of the poses sharing the body weight between the hands and feet. The standing poses, as the name implies would primarily be distributing the weight on the feet. As Figure 3.1 illustrates, the sun salutation have higher METs values (mean METs value and SD =  $5.8 \pm 1.3$ ) compared to the standing poses ( $4.8 \pm 0.9$  METs).

In the present study the mean METs of 4.7 is significantly greater than the 3.0 METs required to achieve health benefits. However, past studies have shown that the intensity and energy expenditure of yoga were not great enough to elicit cardiovascular improvements (DiCarlo et al. 1995; Clay et al., 2005; Hagins et al., 2007). DiCarlo et al. (1998) used a 32-minutes Iyengar routine (Hatha yoga) consisting of all standing poses. In between poses participants jumped back to *tadasana* (mountain pose where you stand tall and steady with your feet together in one spot). Although this study reported an average METs of 4.1, it was reported that this was “not vigorous enough to be considered an exercise to increase aerobic capacity of conditioned individuals. However, the cardiovascular overload coupled with flexibility, strength, and motor control demands does appear to qualify Hatha yoga as an exercise form that can improve overall fitness” (DiCarlo et al., 1998). This study had a slightly lower MET value than the current study (4.7 MET), which could be explained by the stationary standing poses being executed in between poses rather than a vinyasa (see Appendix B). In the DiCarlo et al. study the practitioner would perform a pose and return to standing, which essentially acts a rest pose. In the current study poses “flow” or lead directly into the next poses with no rest in between causing the energy expenditure to increase.

Clay et al. (2005) found even lower METs during yoga. They reported METs as being less than half as much as the current study (mean METs =  $2.17 \pm 0.39$  vs  $4.7 \pm 1.0$ ). The yoga

routine tested by Clay et al. only had 20 minutes of “conditioning” poses of which 5 minutes were sun salutations. Of the 15 minutes of conditioning poses remaining approximately 35% were floor poses that would elicit lower energy expenditure. This study also did not perform vinyasas to transition from one pose to the next. Clay et al. (2005) stated that, “further analysis revealed that the sun salutations asanas increased exercise intensity well above average values. A Hatha yoga session comprised mainly of sun salutations and series of asanas similar to the sun salutations will greatly increase energy expenditure”. This essentially describes Vinyasa yoga which involves sun salutations and poses similar to sun salutations.

Clay et al. (2005) showed that, based on the ACSM guidelines, the %  $\text{VO}_2\text{R}$  during a yoga session was too low to improve cardiorespiratory fitness,  $14.50\% \pm 5.94$ . The current study showed that the practitioners were working on average at a  $\text{VO}_2\text{R}$  percentage of  $35.83 \pm 7.80$  over the entire yoga routine. To break it down further the mean %  $\text{VO}_2\text{R}$  during the sun salutations was  $47.21 \pm 0.56$ , during the standing poses was  $38.90 \pm 7.72$  and during the seated poses it was  $21.37 \pm 7.13$ . The ACSM guidelines states that an individual with a  $\text{VO}_{2\text{max}}$  of 40 – 50 mL/kg/min needs to be working at an intensity of at least 45% oxygen uptake reserve in order to improve  $\text{VO}_{2\text{max}}$  (Garber et al., 2011). Half of the participants in the current study had  $\text{VO}_2\text{max}$  scores of less than 40 mL/kg/min, six participants were in between 40 – 50 mL/kg/min and two were above 50 mL/kg/min. Since the participants were working at a higher  $\text{VO}_2\text{R}$  during the sun salutations there is the possibility to improve  $\text{VO}_{2\text{max}}$  for the majority of them.

Ashtanga, the type of yoga studied by Hagins et al. (2007) falls under the umbrella of Vinyasa yoga. Ashtanga yoga follows a set series of poses whereas Vinyasa or power flow yoga can vary. The average METs during the study by Hagins et al. was  $2.5 \pm 0.8$  for the whole yoga routine versus the current study which was quite a bit higher ( $4.7 \pm 1.0$  METs). In Hagins et al

(2007), the intermediate to advanced participants completed a set beginner Ashtanga routine and during the standing pose routine there were less poses executed and they were carried out at a slower rate than the current study. This could contribute to the lower METs value. This group also reported that although the %MHR throughout the yoga routine was too low to elicit cardio-respiratory fitness based on the ACSM Position Stand, the %MHR during the sun salutations ( $54.8 \% \pm 11.8$ ) was not significantly different than the minimum of 55% of MHR. In the current study the %MHR during the sun salutations was  $54.6 \pm 7.0 \%$  which was not significantly different than 55%,  $p = 0.836$ .

A recent study that measured the energy demand of sun salutations (Mody, 2011) demonstrated that the average METs were  $6.3 \pm 1.4$ , the average energy expenditure was 6.7 kcal/min, and the average age-predicted %MHR was 80.0. These results are very similar to the average METs and kcal/min of the sun salutations in the current study,  $6.0 \pm 1.2$  and  $6.8 \pm 2.1$ , respectively. According to Mody (2011), the intensity of the sun salutations would fall into the zone which would elicit improvements to cardiorespiratory fitness.

Although the intensity in the current study is enough to achieve health benefits, it may not be high enough to improve cardiorespiratory fitness in trained individuals. It appears as though it might be intense enough to improve cardiovascular fitness in unconditioned participants. Participants with a  $VO_{2max}$  below 40 mL/kg/min can improve  $VO_{2max}$  with intensities as low as 28 – 32 %  $VO_{2R}$ . Participants with  $VO_{2max}$  values above 40 mL/kg/min need an intensity above 45%  $VO_{2R}$  to see any improvements (Swain & Franklin, 2002). The % $VO_{2R}$  in sun salutations in the current study just meets the minimum with 47.2%  $VO_{2R}$  but the rest of the routine does not.

## 4.2 Beginner versus Advanced

Group by time interactions were not evident in any of the measures when advanced and beginner practitioners were compared doing the same beginner routine. There was, however, a group main effect for breathing frequency and ventilatory equivalent for oxygen.

In regards to energy expenditure, the advanced practitioners would be expected to be more efficient and expend less energy than the beginner practitioners while completing the same routine. This was not the case in the current study (see Table 3.2) as no significant difference between advanced and beginner yoga practitioners in METs, kcal and heart rate measures were found. This could have been for a combination of reasons. It may be that the advanced group was more efficient but the lowering of energy expenditure was cancelled out by the participants going deeper into the pose (executing a lower position by having more of a bend in the knees) or isometrically contracting more, which would tend to increase energy expenditure.

Increased flexibility, which would reduce passive torque, can increase movement efficiency by reducing the resistance to joint movement and conserve energy (Terada, Wagatsumal, & Kraemer, 1997). Advanced practitioners would potentially be able to conserve energy due to their assumed greater flexibility and efficiency. On the other hand, if a participant has greater flexibility it would also be expected that they would be able to go deeper into a pose thereby making the movement more challenging. As Xiong et al. (2013) stated with the advanced Tai Chi practitioners, the poses could be executed at a lower positioning therefore requiring a great muscle contraction of the lower extremities. The amount of muscles one isometrically contracts in a pose would also change the energy expenditure. A common cue in yoga is to “hug your muscles to the bone” meaning to stabilize the joint by activating the agonist and antagonist muscles surrounding the area. As one improves in their yoga practice they are more aware of

individual contractions of muscles and increase the isometric contractions in the pose. One is also encouraged to activate the “bandhas” or the abdominal muscles and the muscles of the trunk. A beginner may not remember to always be activating these muscles but an advanced practitioner would be expected to do so therefore increasing the energy expenditure. A combination of the advanced practitioner being more efficient but carrying out the pose at a lower position and with more muscles isometrically contracting may account for the lack of difference between beginner and advanced practitioners in measures of energy expenditure while completing the same yoga routine.

The one study that compared beginner and advanced groups completing the same Hatha yoga routine was consistent with ours in that it found no difference in cardiac output, diastolic blood pressure, systolic blood pressure and mean blood pressure between groups (Miles, et al., 2013). They also didn't find any differences between skill groups in rating of perceived exertion, which was consistent with the current study.

There was a difference in breathing measures between the beginner and advanced groups while completing the same beginner routine. The beginner group had significantly higher breathing frequency ( $p = 0.02$ ) and ventilatory equivalent for oxygen ( $p = 0.047$ ). This may suggest that advanced practitioners are more efficient in their breathing than beginners. It is expected that the advanced group would be using Ujjayi breathing throughout the beginner routine. This focuses on a deep, slow breath, which would explain why the advanced group had lower breaths per minute than the beginner group. Ventilatory equivalent for oxygen is the volume of exhaled air per minute divided by the oxygen consumption per minute. This can be a measure of efficiency of the oxygen uptake in the body. If the subject is efficient at using oxygen then not as much air will be needed to sustain a particular level of  $\text{VO}_2$  therefore decreasing the



ventilatory equivalent for oxygen. Ujjayi breath could help explain the lower levels of ventilatory equivalent for oxygen in the advanced group. While executing Ujjayi breath, one constricts the glottis in the throat which would allow the air to remain in the lungs for a slightly longer period allowing more time for the oxygen to perfuse into the lungs. This constriction in the throat would also increase the pressure in the lungs again aiding the air to be absorbed into the blood in the lungs. Long, deep breath as opposed to short, shallow breaths would take advantage of the non-dead space area in the lungs. This could also explain lower ventilatory equivalent in the advanced group.

While the beginner and advanced practitioners completed a skill-appropriate routine, the only significant group by time interaction was for percent heart rate reserve,  $p = 0.033$ . This demonstrates the beginner group responds differently in % HRR than the advanced group to different sections of poses. For the advanced group there was a significant difference between all 3 times points (see Table 3.4); this is consistent with the other measures in that all were significantly different between time points. For the beginners though, the only times points that were significantly different in % HRR were the standing poses and the floor poses. As seen in Figure 3.4 in the result section, during the floor poses the % HRR for the beginner group did not drop all that much (26.0 %) making it not that different from the sun salutations (29.7 %). It could be speculated that the beginner group may not be accustomed to using relaxation techniques during the floor poses which could help decrease %HRR. Also possible was that difference in difficulty between the beginner routine and the advanced routine was not large enough. The beginner routine may have been too hard or the advanced routine was too easy thereby making it difficult to tease out any differences between the two skill levels. The two routines were chosen to simulate what one would find in a typical all-levels class with options

given for both the beginner and advanced practitioner. Perhaps in future research two separate class routines should be used; one catering more explicitly to beginners and the other catering to advanced practitioners.

Participant numbers were low and it appears as though statistical power was lacking. The results of the sample size calculation based on 80% power, which was done prior to the start of the study, suggest that there be 13 participants in each skill group (See section 2.1, p. 12). The current study only had 8 participants per group. When a post-hoc sample size calculation was done (see section 3.5, p. 43), it was determined that a sufficient number of participants per group would be 14. This is similar to the *a priori* calculation that was done which suggested 13 per group. With this lack of power, the null hypothesis that there are no differences in metabolic demands between beginner and advanced yoga practitioners cannot be ruled out.

#### **4.3 Males versus Females**

The males on average expended significantly more kilocalories per minute than females throughout the whole yoga session. This is expected since the males weigh more than the females ( $p < 0.01$ ) and most likely have more muscle mass than the females. Males also worked at a significantly higher MET value while everyone was completing the beginner routine but not while completing the skill-appropriate yoga routine. Since METs are relative to weight they are a better indicator of intensity despite sex. Tidal volume was also significantly greater in males than females, which comes as no surprise since males generally have larger lungs than females.

All these differences between males and females are to be expected. There were no significant 3-way interactions between time, sex and skill group meaning regardless of sex, the practitioners responded similarly to the different types of yoga poses.

## 4.4 Strengths

To my knowledge this was the first study to look at the intensity and energy expenditure of a full length Vinyasa or Power Yoga routine. Prior to this only portions, like the sun salutations (Carroll et al., 2003, Mody, 2010), have been measured for energy expenditure. If a whole routine had been tested it was for heart rate only (Cowen & Adams, 2007) and not for any other metabolic measures. This study is novel in that it measures breath-by-breath values such as  $\text{VO}_2$  and  $\text{VCO}_2$  in real time using a portable indirect calorimetry system. The use of a harness to place the light-weight portable unit directly on the participant negates the use of long cords and tubes which could impede movement. With this system the participant can breathe and move freely allowing the participants to mimic a more real-world situation.

It is rare that any of the past studies have looked at the differences of physiological factors in yoga practitioners of different skill level. One such study looked at the difference between beginner and advanced yoga practitioners (Miles, et al., 2013) but only explored heart rate and blood pressure. The current study was able to obtain valuable measures like METs, kcals, % of  $\text{VO}_2$  max and % HRR. It is important to discover a basic understanding of this type of yoga and how it may differ between beginner to an advanced practitioners.

To compare the results of this study to the Canadian Physical Activity guidelines translates these findings so it is more accessible to the general public. It is easier to understand the intensity (mild, moderate or vigorous) of an exercise as opposed to the raw values such as  $\text{VO}_2$  or %HRR. Since so few Canadians are meeting the Physical Activity Guidelines, the results of this study give the public another option to satisfy the minimum physical activity recommendations. Determining the intensity of Vinyasa yoga allows for the public and/ or health

care providers to make more informed decision of whether Vinyasa yoga is appropriate for an individual's fitness and/ or health needs.

#### **4.5 Limitations**

One of the limitations of the study would be the low numbers in the beginner and advanced groups. This small sample size increases the chance of type II error, which in this case would be failing to detect a significant difference between skill levels even if there is one.

Vinyasa yoga is known for its variation in sequencing and from teacher-to-teacher and class-to-class. Due to this there could be a large variation in the energy expenditure from one Vinyasa yoga class to the next. An attempt was made in this study to demonstrate a “typical” Vinyasa yoga class. Even with the exact same sequence and teacher there may be a variation in energy expenditure from one session to the next. The practitioner can potentially affect the intensity by controlling the effort level. Motivation and energy level could have an effect on energy expenditure.

Motivation may vary from a practitioner completing a yoga routine alone with a video-led class versus a class surrounded by other practitioners and a face-to-face yoga instructor. One may be more motivated in the presence of a teacher giving feedback and surrounded by other practitioners. The researcher was always present but did not give any verbal feedback and watched from a distance so as not to disturb.

Fat free mass was not measured in this study. Body mass index ( $\text{weight/height}^2$ ) was used to estimate body composition. The metabolic demand of an exercise can vary from person to person based on the amount of muscle mass and fat mass they have.

## **4.6 Recommendations for Future Research**

To determine if Vinyasa yoga can in fact improve cardiovascular fitness randomized controlled trials of participants completing Vinyasa yoga multiple sessions a week, with a larger sample size, would be recommended. Further research should be done to mimic an in-class setting as this may give more accurate results.

Since little is still known about the mind-body connection further research is needed to determine how the relaxation component of yoga affects the physiology of the body. Pilates is another exercise modality that has limited information available about its metabolic demands and a study with a similar protocol could be used.

## **4.7 Conclusion**

The metabolic demand of a typical Vinyasa yoga session is moderate in intensity and therefore can meet the Canadian Physical Activity Guidelines and give health benefits if it is performed 3 times per week. This type of yoga can be used to meet the guidelines if other modes of exercise are not desired or it can be used to supplement a current workout regime. Beginner and advanced practitioners demonstrated similar physiological responses to Vinyasa yoga for both beginner routines and skill-level appropriate routines but the advanced group did show some evidence of being more efficient in their breathing patterns. By knowing the intensity of Vinyasa yoga, better decisions by the yoga practitioner and more informed recommendations by health care providers can be made on whether Vinyasas yoga is suitable for an individual's fitness level and health needs.

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## **Appendices**

### **Appendix A - Eight Limbs of Yoga**

#### 1) Yamas

- a. Ahimsa (non-violence)
- b. Satya (truthfulness)
- c. Astaya (non-stealing)
- d. Brahmacharya (celibacy or control of energy)
- e. Aparigraha (non-covetousness)

#### 2) Niyamas

- a. Saucha (cleanliness)
- b. Samtosa (contentment)
- c. Tapas (spiritual austerity)
- d. Svadhyaya (study of one's self and sacred scriptures)
- e. Isvara pranidhana (surrender to god)

#### 3) Asana – the physical postures

#### 4) Pranyama – breath control and breathing techniques

#### 5) Pratyahara – withdrawal of the senses

#### 6) Dharana – Concentration

#### 7) Dyana – Meditation or contemplation

#### 8) Samadhi – State of ecstasy

## Appendix B – Sequence of Poses in a Vinyasa

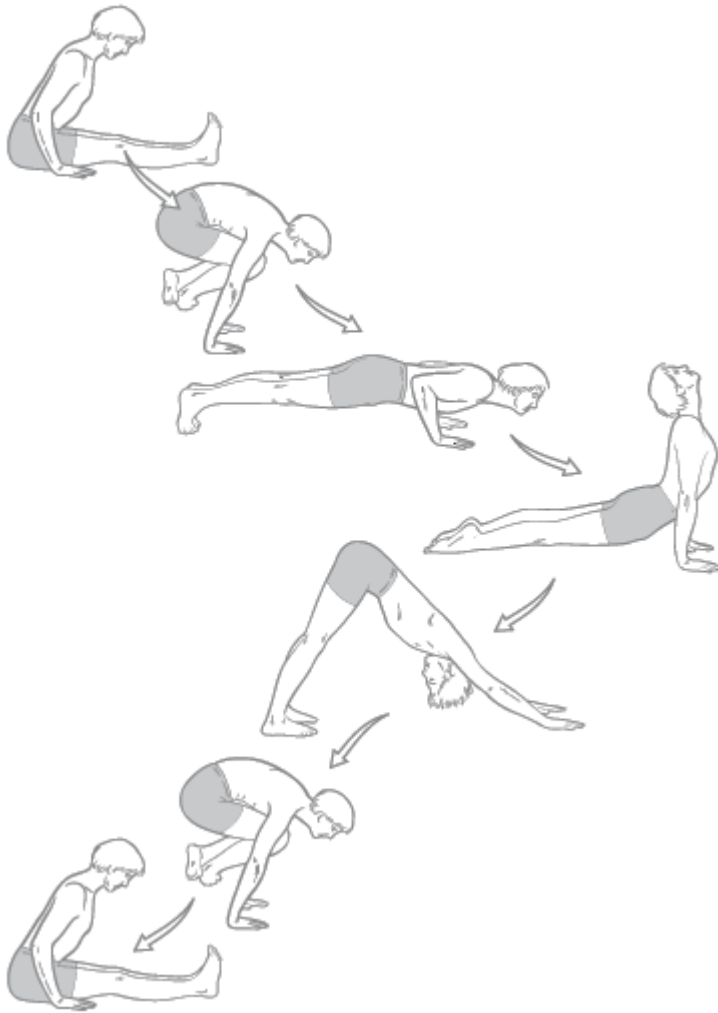


Image taken with permission from Cowan & Adams, 2004

## **Appendix C – Consent Form**



### **SUBJECT INFORMATION AND CONSENT FORM**

**STUDY TITLE:** The Metabolic Demands of Vinyasa Yoga

**PRINCIPAL INVESTIGATOR:** Dr. Philip Chilibeck, Ph.D., Professor, College of Kinesiology,  
University of Saskatchewan

**SUB-INVESTIGATORS and/or STUDENT RESEARCHERS:** Julianne Rooke, Msc. Candidate,  
College of Kinesiology, University of Saskatchewan

**SPONSOR [or Funding Agency]:** N/A

**CONTACT PHONE NUMBER:** 966-1072 (Phil Chilibeck), 966-1082/220-1887 (Julianne Rooke)

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## **INTRODUCTION**

You are invited to take part in this research study. The purpose of this study is to determine the intensity and how much energy you would use while completing a 90-minute vinyasa yoga routine. Vinyasa yoga is characterized by the breath moving you into and out of the postures in a steady and continuous rhythm. The second purpose of the study is to compare the differences in energy cost between beginner yoga practitioners and advanced yoga practitioners while completing a 90-minute vinyasa yoga routine.

Your participation is voluntary. It is up to you to decide whether or not you wish to take part. If you wish to participate, you will be asked to sign this form. If you do decide to take part in this study, you are still free to withdraw at any time and without giving any reasons for your decision.

If you do not wish to participate, it will not affect your relationship with any of the investigators.

Please take time to read the following information carefully. You can ask the researcher to explain any words or information that you do not clearly understand. You may ask as many questions as you need. Please feel free to discuss this with your family, friends or family physician before you decide.

## **WHY IS THIS STUDY BEING DONE?**

This study is being done to determine if a 90 minute vinyasa yoga session would have a high enough intensity to give health benefits. This will be based on the Canadian Physical Activity Guidelines which

state adults between the age of 18 and 64 require at least 150 minutes of moderate to vigorous physical activity a week. This has to be done in bouts of ten minutes or more.

### **WHO CAN PARTICIPATE IN THE STUDY?**

You are eligible to participate in this study if you are between the ages of 18 and 45. We are looking for beginner and advanced yoga practitioners. A beginner would qualify as someone who has been doing yoga for fewer than 6 months. For safety reasons, we would like all beginners to have at least a month of formal practice with a yoga instructor. An advanced practitioner would be someone who has been consistently practicing for at least 2 years and: a) performs ojjayi breathing (a breathing method meant to be executed throughout the yoga practice), b) are comfortable doing inversions (headstand, shoulder stand), and c) are competent in completing sun salutations. All subjects will be free of any injuries or limitations that would prevent them from completing the testing protocol.

### **WHAT DOES THE STUDY INVOLVE?**

First you will do an exercise test on a treadmill to determine your aerobic fitness level. This test will progress in intensity until you cannot run anymore. It will last around 6 – 12 minutes. On a separate lab

visit, you will complete a 90-minute vinyasa yoga routine that you will be following on a video recording. During this yoga routine, we will not be taking any measurements. It is a chance for you to become familiar with the yoga routine. After at least 4 days of rest, you will complete the same yoga routine but this time with all the measurements being taken.

During all the tests you will be wearing a portable gas exchange apparatus. This is a measurement tool that will show how much oxygen you are breathing in and how much carbon dioxide you are breathing out. This apparatus involves you breathing into a facemask that covers your mouth and nose. The facemask is attached to a transmitter that you will be wearing around your waist. You will be wearing a heart rate monitor throughout all the tests. Throughout the yoga session, you will be asked to rate on a scale of 1 – 10 how hard you are working.

The total time commitment for the study is approximately 3 ½ hours.

#### **WHAT ARE THE BENEFITS OF PARTICIPATING IN THIS STUDY?**

If you choose to participate in this study, there may or may not be direct benefits to you. It is hoped the information gained from this study can be used in the future to benefit other people in a similar situation. You will get an evaluation of your aerobic fitness. You will not receive any payment nor be charged a cost for your participation in this study.

#### **ARE THERE POSSIBLE RISKS AND DISCOMFORTS?**

If you choose to participate in this study, the following are possible. The exercise may result in muscle pulls or strains, or muscle soreness. You will be given a proper warm-up prior to exercising and this will minimize this risk and all exercise tests.

Other risks during difficult exercise testing include fainting or heart attacks, but these are very rare. There may be unforeseen and unknown risks during the study, or after the study has been completed.

#### **WHAT HAPPENS IF I DECIDE TO WITHDRAW?**

Your participation in this research is voluntary. You may withdraw from this study at any time. You do not have to provide a reason. There will be no penalty or loss of benefits if you choose to withdraw. Your relationship with the investigator will not be affected.

If you choose to enter the study and then decide to withdraw later, all data collected about you during your enrolment will be retained for analysis.

All research records pertaining to the study will be retained for not less than 5 years from the date of the publication of a research report.



### **WILL I BE INFORMED OF THE RESULTS OF THE STUDY?**

The results of the study will be available in the winter of 2011/2012 from Julianne Rooke. Your personal results will be shared with you if requested. We will apply to have the study results published in a scientific journal as well as have them published in the form of a thesis.

### **WHAT HAPPENS IF SOMETHING GOES WRONG?**

By signing this document, you do not waive any of your legal rights. In the case of a medical emergency related to the study, you should seek immediate care and, as soon as possible, notify the study investigators.

### **WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?**

While absolute confidentiality cannot be guaranteed, every effort will be made to ensure that the information you provide for this study is kept entirely confidential. Your name will not be attached to any information, nor mentioned in any study report, nor be made available to anyone except the research team. It is the intention of the research team to publish results of this research in scientific journals and to present the findings at related conferences and workshops, but your identity will not be revealed. Because of the intense exercise involved in the study, we are asking your permission to contact your family physician to inform him/her about your participation in the study.

### **WHO DO I CONTACT IF I HAVE QUESTIONS ABOUT THE STUDY?**

If you have any questions or desire further information about this study before or during participation, you can contact Julianne Rooke at 966-1082/220-1887 or Phil Chilibeck at 966-1072

If you have any concerns about your rights as a research subject and/or your experiences while participating in this study, contact the Chair of the University of Saskatchewan Research Ethics Board, at 306-966-4053. The Research Ethics Board is a group of individuals (scientists, physicians, ethicists, lawyers and members of the community) that provide an independent review of human research studies. This study has been reviewed and approved on ethical grounds by the University of Saskatchewan Research Ethics Board.



## CONSENT TO PARTICIPATE

### Study Title: The Metabolic Demands of Vinyasa Yoga

- I have read (or someone has read to me) the information in this consent form.
- I understand the purpose and procedures and the possible risks and benefits of the study.
- I was given sufficient time to think about it.
- I had the opportunity to ask questions and have received satisfactory answers.
- I understand that I am free to withdraw from this study at any time for any reason and the decision to stop taking part will not affect my future relationships.
- I give permission to the use and disclosure of my de-identified information collected for the research purposes described in this form.
- I understand that by signing this document I do not waive any of my legal rights.
- I will be given a signed copy of this consent form.
- I agree that my family physician can be contacted about my participation in this study:
  - \_\_\_\_ Yes                      \_\_\_\_ No OR I do not have a family physician

I agree to participate in this study:

Printed name of participant:

Signature

Date

Printed name of person obtaining consent:

Signature

Date

## Appendix D – PAR Q & You

Physical Activity Readiness  
Questionnaire - PAR-Q  
(revised 2002)

# PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition <b>and</b> that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of <b>any other reason</b> why you should not do physical activity?

If  
you  
answered

### YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

### NO to all questions

- If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
  - take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

#### DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

**Informed Use of the PAR-Q:** The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

**No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.**

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME \_\_\_\_\_

SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_

SIGNATURE OF PARENT  
or GUARDIAN (for participants under the age of majority) \_\_\_\_\_

WITNESS \_\_\_\_\_

**Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.**



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# PAR-Q & YOU

Physical Activity Readiness  
Questionnaire - PAR-Q  
(revised 2002)

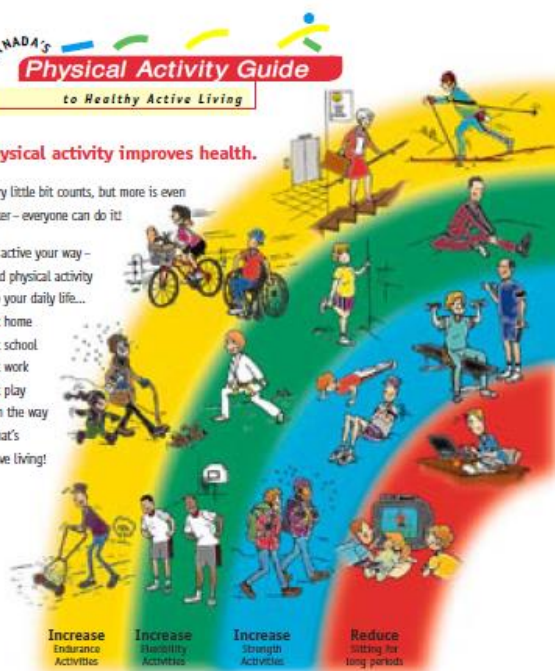
## CANADA'S Physical Activity Guide to Healthy Active Living

### Physical activity improves health.

Every little bit counts, but more is even better – everyone can do it!

Get active your way – build physical activity into your daily life...

- at home
- at school
- at work
- at play
- on the way
- ...that's active living!



Increase  
Endurance  
Activities

Increase  
Flexibility  
Activities

Increase  
Strength  
Activities

Reduce  
Sitting for  
long periods

Choose a variety of activities from these three groups:

#### Endurance

4-7 days a week  
Continuous activities for your heart, lungs and circulatory system.

#### Flexibility

4-7 days a week  
Gentle reaching, bending and stretching activities to keep your muscles relaxed and joints mobile.

#### Strength

2-4 days a week  
Activities against resistance to strengthen muscles and bones and improve posture.

Starting slowly is very safe for most people. Not sure? Consult your health professional.

For a copy of the Guide Handbook and more information: 1-888-334-9769, or [www.paguide.com](http://www.paguide.com)

Eating well is also important. Follow Canada's Food Guide to Healthy Eating to make wise food choices.

### Get Active Your Way, Every Day – For Life!

Scientists say accumulate 60 minutes of physical activity every day to stay healthy or improve your health. As you progress to moderate activities you can cut down to 30 minutes, 4 days a week. Add-up your activities in periods of at least 10 minutes each. Start slowly... and build up.

Time needed depends on effort			
Very Light Effort	Light Effort	Moderate Effort	Vigorous Effort
60 minutes	30-60 minutes	20-30 minutes	10-20 minutes
• Strolling • Dusting	• Light walking • Volleyball • Easy gardening • Shopping	• Brisk walking • Biking • Raking leaves • Swimming • Dancing • Water aerobics	• Aerobics • Jogging • Hockey • Basketball • Fast swimming • Fast dancing
Range needed to stay healthy			

### You Can Do It – Getting started is easier than you think

Physical activity doesn't have to be very hard. Build physical activities into your daily routine.

- Walk whenever you can – get off the bus early, use the stairs instead of the elevator.
- Reduce inactivity for long periods, like watching TV.
- Get up from the couch and stretch and bend for a few minutes every hour.
- Play actively with your kids.
- Choose to walk, wheel or cycle for short trips.
- Start with a 10 minute walk – gradually increase the time.
- Find out about walking and cycling paths nearby and use them.
- Observe a physical activity class to see if you want to try it.
- Try one class to start – you don't have to make a long-term commitment.
- Do the activities you are doing now, more often.

#### Benefits of regular activity:

- better health
- improved fitness
- better posture and balance
- better self-esteem
- weight control
- stronger muscles and bones
- feeling more energetic
- relaxation and reduced stress
- continued independent living in later life

#### Health risks of inactivity:

- premature death
- heart disease
- obesity
- high blood pressure
- adult-onset diabetes
- osteoporosis
- stroke
- depression
- colon cancer

Health Canada Santé Canada

Canadian Society for Exercise Physiology



For more information, please contact the:



Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 <http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf>

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### FITNESS AND HEALTH PROFESSIONALS MAY BE INTERESTED IN THE INFORMATION BELOW:

The following companion forms are available for doctors' use by contacting the Canadian Society for Exercise Physiology (address below):

The **Physical Activity Readiness Medical Examination (PARmed-X)** – to be used by doctors with people who answer YES to one or more questions on the PAR-Q.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy)** – to be used by doctors with pregnant patients who wish to become more active.

#### References:

- Arraiz, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. *J. Clin. Epidemiol.* 45:4 419-428.
- Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy. In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health**. Champaign, IL: Human Kinetics.
- PAR-Q Validation Report, British Columbia Ministry of Health, 1978.
- Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Can. J. Sport Sci.* 17:4 338-345.

For more information, please contact the:

Canadian Society for Exercise Physiology  
202-185 Somerset Street West  
Ottawa, ON K2P 0J2  
Tel. 1-877-651-3755 • FAX (613) 234-3565  
Online: [www.csep.ca](http://www.csep.ca)

The original PAR-Q was developed by the British Columbia Ministry of Health. It has been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Questionnaire sur l'aptitude à l'activité physique - Q-AAP (révisé 2002)».



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